Staff Report of the

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

CENTRAL VALLEY REGION

AGRICULTURAL DRAINAGE CONTRIBUTION TO WATER QUALITY IN THE GRASSLAND AREA OF WESTERN MERCED COUNTY, CALIFORNIA: OCTOBER 1994 TO SEPTEMBER 1995

(WATER YEAR 1995)

DECEMBER 1996

DISCLAIMER

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EXECUTIVE SUMMARY

In May 1985, the Central Valley Regional Water Quality Control Board (Regional Board) began a water quality monitoring program to evaluate the effects of subsurface agricultural drainage on the water quality of the drains in the Grassland area of western Merced County. This database has been used in the development of agricultural drainage reduction programs in the San Joaquin River Basin and will continue to be used in the future. Reports on this water quality survey have already been prepared and approved by the Regional Board for Water Years (WYs) 1986 through 1994. The current report covers WY 95 (October 1994 through September 1995), the third highest runoff WY since 1906.

The Grassland area comprises over 90,000 acres of wetland habitat located in Merced and Fresno counties on the west side of the San Joaquin River. Agricultural lands east, west, and south of the Grassland Area discharge subsurface agricultural drainage water (tile drainage) and surface irrigation runoff (tail water) into channels that pass through the wetland habitat area. This drainage often contains high concentrations of salts, selenium and other trace elements. This regional drainage flows north through the Grassland Area where it is carried by a network of canals which can divert water in a number of possible ways before it reaches Mud Slough (north) or Salt Slough and ultimately the San Joaquin River.

As in previous studies, this study shows that the highest constituent concentrations are found at the inflow monitoring stations near the southern boundary of the Grassland Area. This inflow is generally a blend of subsurface tile drainage and surface runoff or operational spills from irrigation canals. Four of these inflow points carry a substantial portion of subsurface drainage water and have the highest concentrations of salts, boron, and selenium. Other inflows contain little selenium, however, elevated levels of salt and boron are present.

The selenium levels in Mud and Salt Sloughs vary depending on which slough is conveying subsurface drainage from the Drainage Problem Area[1] (DPA). During WY 95, subsurface drainage was diverted primarily to Salt Slough. The presence of subsurface drainage in Salt Slough resulted in monthly mean selenium concentrations ranging between 6 and 32 μg/L. The concentration of selenium varied with the concentration in the subsurface drainage and with dilution of the drainage by other sources of flow in the slough. In the absence of significant

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[1] Subsurface drainage from the Drainage Problem Area will hereafter be referred to as subsurface drainage. Subsurface drainage is composed of subsurface tile discharges from all of the Broadview, Firebaugh Canal, Pacheco, and Widren Water Districts (WD); all of the Panoche Drainage District and some the area served by the San Luis WD and the Central California Irrigation District.

subsurface drainage discharges to Mud Slough (north), monthly mean selenium levels were less than 2.1 µg/L for WY 95. The management of subsurface drainage into either slough is the main factor determining the selenium concentration.

In 1988, water quality objectives were adopted in the San Joaquin River Basin Plan 5C for selenium, boron, and molybdenum in Mud Slough (north) and Salt Slough. The seasonal monthly mean boron water quality objective is 2.0 mg/L (March 15 to September 15) and the molybdenum objective is 19 µg/L for both sloughs. Boron and molybdenum water quality objectives were not exceeded in Mud Slough (north) during WY 95.

In Salt Slough, the boron objective was exceeded in March, April, and June 1995. Subsurface drainage was one of the primary components of flow in Salt Slough during this period. Data from WYs 91 and 92 indicate that boron concentrations of 2.0 mg/L can be met in Salt Slough when subsurface drainage is excluded. The molybdenum objective was met at all times in Salt Slough.

An analysis of the loads of selenium, boron, and salt from the sloughs and the DPA indicates that the trend toward load reductions which took place between water years 1989 and 1992, was reversed in WYs 93 through 95. Water Year 93 saw increased water supplies in the area that resulted in higher discharges and loads. The high load levels continued during WY 94 in spite of the fact that exchange and federal contractors had their contract deliveries curtailed to near WY 92 drought levels. The WY 95 load levels measured in the San Joaquin River exceeded any loads measured since monitoring began in 1985. The elevated load levels in WY 95 may be attributed to both pre-plant irrigation and unusually high rainfall runoff leading to extremely high loads in February and March. The selenium loads generated during the pre-irrigation and flood season accounted for nearly half of the load produced in WY 95.

All wetland supply sources had selenium concentrations below the 2.0 µg/L water quality objective during the principal flooding period (October). Selenium concentrations did, however, exceed the 2 µg/L objective in two of the subsequent monthly measurements of the CCID Main Canal, reaching a maximum concentration of 3.8 µg/L. It can not be determined if water exceeding the objective was used for wetland maintenance. The source of the selenium in the supply channels is unknown but may have originated in the Delta-Mendota Canal.

Other constituents analyzed during WY 95 (copper, chromium, lead, nickel, and zinc), do not appear to be at concentrations which would impact aquatic life due to the elevated hardness values in the channels surveyed. Selenium, boron, and salt loads as well as concentrations will continue to be reviewed and analyzed in future water years.

INTRODUCTION

The Agricultural Unit of the Central Valley Regional Water Quality Control Board (Regional Board) initiated a water quality monitoring program in May 1985 to evaluate the effects of subsurface agricultural drainage on the water quality of canals, drains, and sloughs in the Grassland Area in western Merced County. The study area is located west of the San Joaquin River between Newman and Oro Loma, in the San Joaquin River Basin in California (Figure 1). The primary purpose of this monitoring program is to determine compliance with applicable water quality objectives and to compile an on-going database for selected inorganic constituents found in the agricultural drains discharging to and flowing through the Grassland Area. The database is used in the development and evaluation of agricultural drainage reduction programs in the San Joaquin River Basin. Information gathered under this program is also being used to develop a predictive model for determining maximum salt, selenium, and boron loads which could be discharged from the study area while still meeting downstream water quality objectives (Karkoski, 1994). This report contains laboratory results and a brief summary of the water quality analysis for samples collected during Water Year 1995 (October 1994 through September 1995). Eight previous reports (James, et al., 1988, Chilcott, et al., 1989, Westcot, et al., 1990, Westcot, et al., 1991, Westcot, et al., 1992, Karkoski and Tucker, 1993, Chilcott et al., 1995, and Vargas, et al., 1995) present data for the period May 1985 through September 1994 (WYs 86-94).

STUDY AREA

The Grassland Area encompasses the Northern and Southern Divisions of the Grassland Water District along with the farmlands adjacent to the District (Figure 1). Land in this area is primarily used for irrigated agriculture and managed wetlands.

Agricultural lands east, west, and south of the Grassland Area discharge subsurface agricultural drainage water (tile drainage) and surface runoff (irrigation tail water) to the Grassland Area. This drainage often contains high concentrations of salts, selenium, and other trace elements. This regional drainage flows north through the Grassland Area where it is carried by a network of canals that can divert water in several possible ways before discharge into either Mud Slough (north) or Salt Slough. The two sloughs are tributary to the San Joaquin River and serve as the primary outlets from the Grassland Area.

There were 32 stations in the Grassland monitoring program as described in previous reports. They were divided into three categories: inflows, internal flows within, and outflows from the Grassland Area. Inflow monitoring stations are located on drains that discharge into the Grassland Area and are mainly located at the southern end of the study area. Monitoring stations on the internal flow canals are located on drains within the Grassland Area that carry or could carry subsurface tile drainage as it passes through the area before discharging to the San Joaquin River. Outflow monitoring stations are located where drains or natural waterways flow out of the Grassland Area. Many of the internal flow stations described in previous reports have been

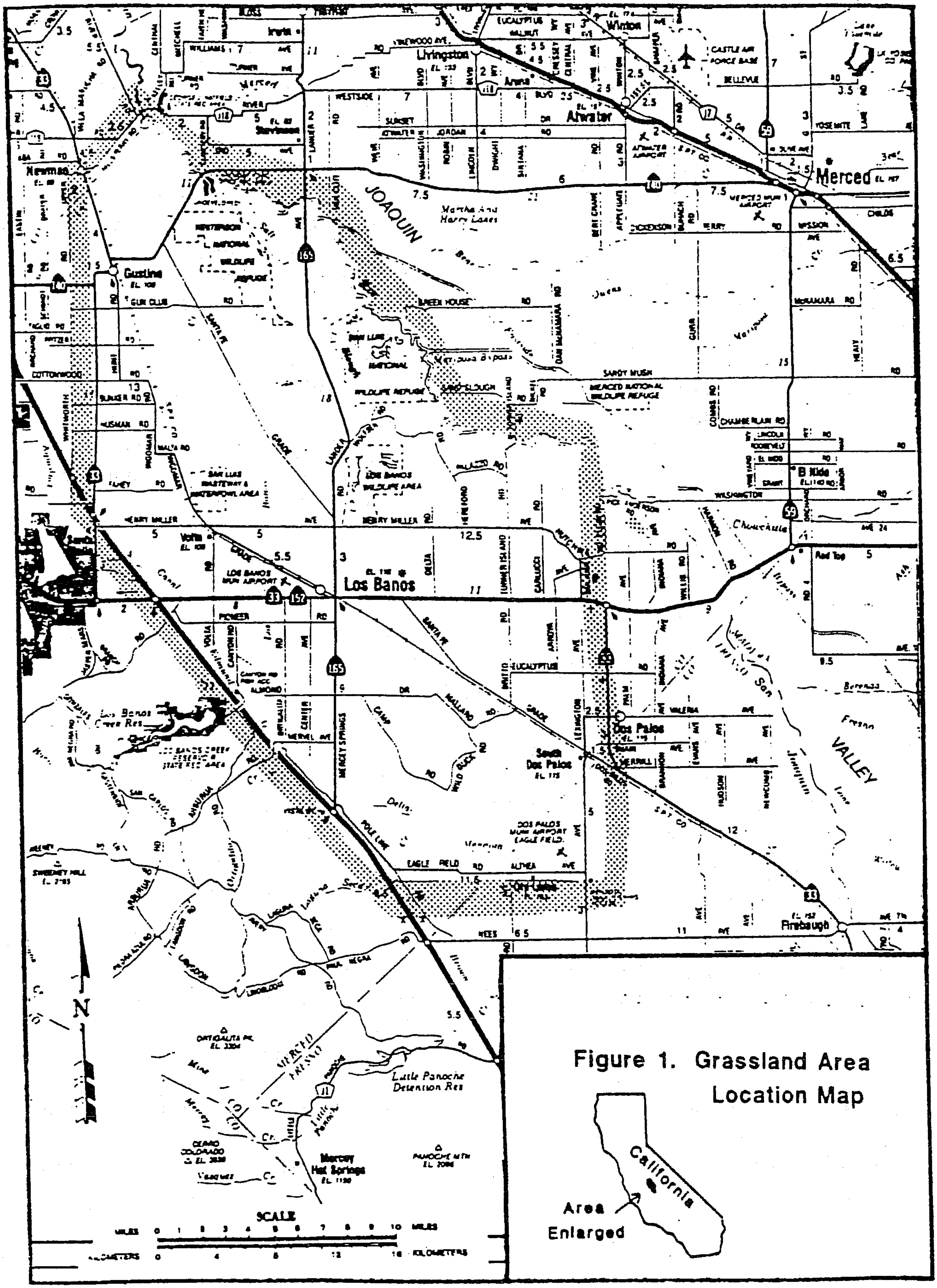


Figure 1. Grassland Area Location Map

altered or dropped from the original monitoring program, while the frequency of monitoring the inflow and outflow sites was expanded.

During WY 95, ten inflow, six internal flow, and four outflow stations were monitored (Table 1 and Figure 2). In addition, samples were collected at the terminus of the San Luis Drain when water had collected at that point. Most of the original inflow stations were maintained during the current survey and have continuous data from May 1985 through September 1995. Internal flow stations are maintained to assess the approximate concentration of selenium in wetland water supply canals to the Grassland Area as well as to track movement of the drainage water. The CCID Main Canal (T-1) is the main water supply to the Grassland Area and local duck clubs and is discussed in this report. The Porter-Blake Bypass (T-13), Santa Fe Canal at Henry Miller Road (T-5), San Luis Canal at Henry Miller Road (T-7A), San Luis Canal at Highway 152 (T-7), and the San Luis Spillway Ditch at Santa Fe Grade (T-14) were also surveyed during WY 95.

Mud Slough (north) and Salt Slough are the primary tributaries to the San Joaquin River that drain the Grassland Area and are described in detail in previous reports. Mud Slough (north) at the San Luis Drain (0-2A) and Salt Slough at Lander Avenue (0-4) are located near continuous flow monitoring stations operated by the U.S. Geologic Survey and are the principal stations in this monitoring program. These two sites best represent the water quality of the drainage leaving the Grassland Area. Los Banos Creek at Highway 140 (0-3) drains into Mud Slough (north) upstream of the San Joaquin River but downstream of the site near the San Luis Drain. Mud Slough at Newman Gun Club (0-1) represents the combined quality of Mud Slough (north) and Los Banos Creek.

METHODS

Sampling

The frequency of sample collection for this monitoring program consisted of weekly, monthly, and quarterly grab samples depending on site location. The sampling frequency and parameters analyzed are outlined in Table 2. Water temperature, pH, electrical conductivity (EC), and sample time were recorded in the field for each site. There were six sites sampled weekly and an additional fifteen sites sampled either monthly or quarterly. Laboratory analyses for total recoverable selenium, boron and EC[2] were performed on all samples. Selected sites were also monitored for copper, chromium, nickel, lead, zinc and molybdenum on a monthly or quarterly basis. Sampling frequency was reduced to quarterly at stations which had shown consistent constituent concentrations between WY 86 and WY 94. During WY 95, the Regional Board began using composite samplers at some select monitoring sites. This data will be available in future reports.

[2] Electrical conductivity values reported in the Appendices are laboratory EC values.

Table 1. Water Quality Monitoring Sites in the Grassland Area for Water Year 1995

Map Index	RWQCB Site I.D.	Site Name	Site Type
I-1	MER 556	Main (Firebaugh) Drain @ Russel Ave.	Inflow
I-2	MER 501	Panoche Drain	Inflow
I-4	MER 506	Agatha Canal @ Mallard Rd.	Inflow
I-6	MER 504	Hamburg Drain	Inflow
I-7	MER 505	Camp 13 Slough	Inflow
I-8	MER 502	Charleston Drain	Inflow
I-9	MER 555	Almond Drive Drain	Inflow
I-10	MER 509	Rice Drain	Inflow
I-11	MER 521	Boundary Drain	Inflow
I-12	MER 528	Salt Slough Ditch @ Hereford Road	Inflow
T-1	MER 510	CCID Main @ Russell Ave.	Internal Flow
T-5	MER 519	Santa Fe Canal @ Henry Miller Road	Internal Flow
T-7A	MER 543	San Luis Canal @ Henry Miller Road	Internal Flow
T-7	MER 527	San Luis Canal @ Highway 152	Internal Flow
T-13	MER 548	Porter-Blake Bypass	Internal Flow
T-14	MER 537	San Luis Spillway Ditch @ Santa Fe Grade	Internal Flow
O-1	MER 551	Mud Slough (N) @ Newman Gun Club	Outflow
O-2A	MER 542	Mud Slough (N) @ San Luis Drain	Outflow
O-3	MER 554	Los Banos Creek @ Highway 140	Outflow
O-4	MER 531	Salt Slough @ Lander Avenue	Outflow
SLD-1	MER 534	San Luis Drain @ Highway 152	Special Study

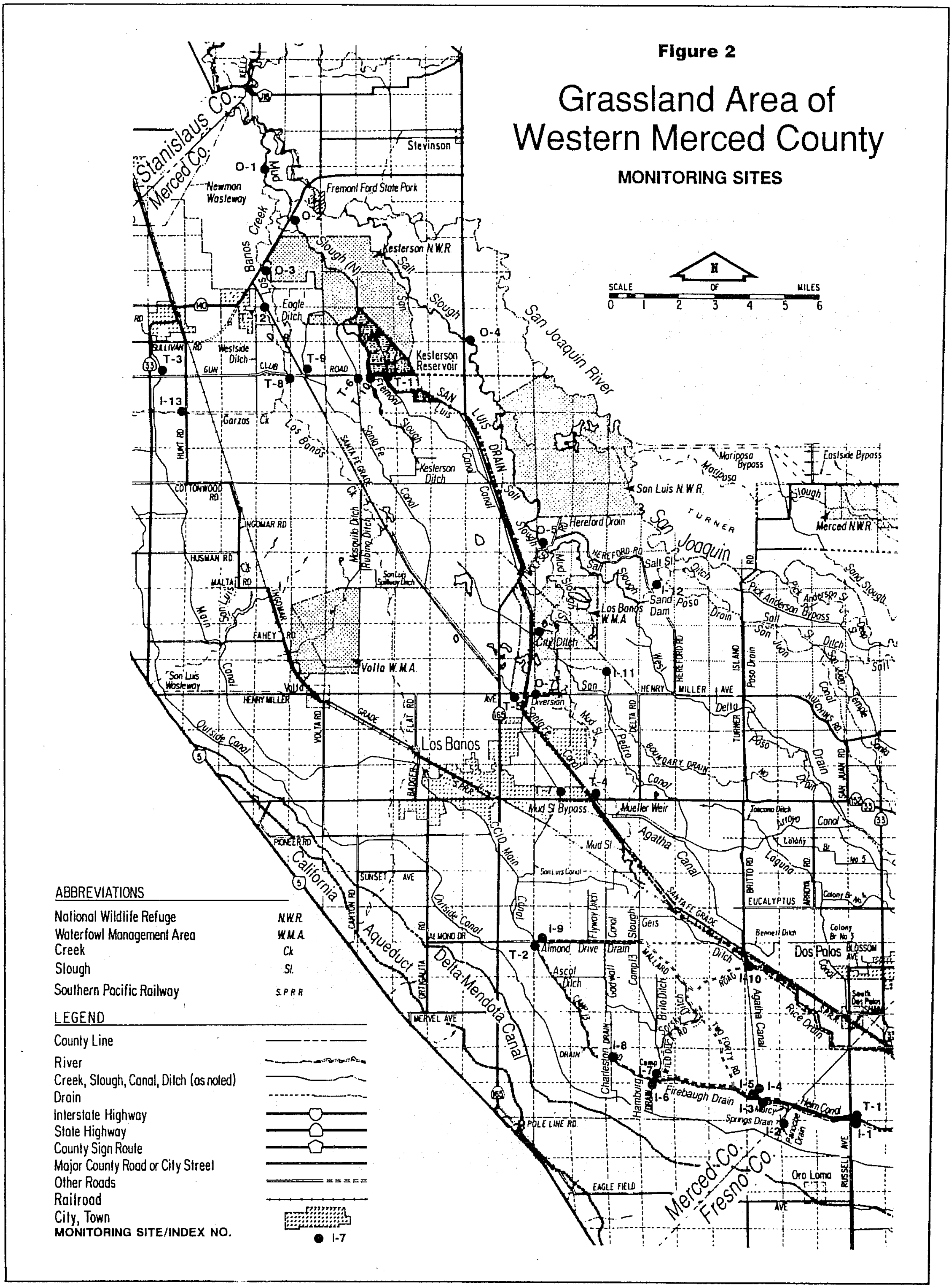


Figure 2

Grassland Area of Western Merced County

MONITORING SITES

Table-2 Sampling Frequency and Parameters Analyzed in the Grasslands Area During Water Year 1995

Site	Parameters Analyzed and Frequency											
	pH	EC	temp	Se	Mo	Cr	Cu	Pb	Ni	Zn	B	Part Min
Main (Firebaugh) Drain @ Russel Avenue	W	W	W	W	Q						W	M
Panoche Drain	W	W	W	W	Q						W	M
Agatha Canal	M	M	M	M								M
Hamburg Drain	W	W	W	W	Q						W	M
Camp 13 Slough	M	M	M	M								M
Charleston Drain	W	W	W	W	Q						W	M
Almond Drive Drain	M	M	M	Q								M
Rice Drain	M	M	M	Q								Q
Boundary Drain*	M	M	M	M								M
Salt Slough @ Hereford Road	M	M	M	Q								Q
CCID Main Canal	M	M	M	Q								Q
Santa Fe Canal @ Henry Miller Road	M	M	M	M								M
San Luis Canal @ Highway 152*	M	M	M	M								M
San Luis Canal @ Henry Miller Road	M	M	M	M								M
Porter Blake Bypass	M	M	M	M								M
San Luis Spillway Ditch @ Santa Fe Grade*	M	M	M	M								M
Mud Slough @ Newman Gun Club	M	M	M	M								M
Mud Slough @ San Luis Drain	W	W	W	W	Q	Q	Q	Q	Q	Q	W	M
Los Banos Creek @ Highway 140	M	M	M	Q								Q
Salt Slough @ Lander Avenue	W	W	W	W	Q	Q	Q	Q	Q	Q	W	M
San Luis Drain @ Highway 152*	M	M	M	M								M

W=Weekly
M=Monthly
Q=Quarterly (Oct, Jan, Apr, Jul)
Part Min= Cl, SO4, and Hardness, Boron
Full Min= Ca, Mg, Na, K, Cl, SO4, HCO3, CO3, Hardness, Alkalinity, TDS, EC, pH, boron
* Sampling discontinued 2-23-95

Samples were collected in polyethylene bottles. The selenium and trace element sample bottles were rinsed with dilute nitric acid and deionized water in the laboratory before use. All sample bottles were rinsed three times with the water to be sampled prior to sample collection. Selenium, boron, and trace element samples were preserved by lowering the pH to less than two within 24 hours of collection using reagent grade nitric acid. All samples were kept on ice until preservation and/or submittal for analyses.

A quality control and quality assurance program was conducted using blind split and spiked samples. Blind split samples were collected at a ten percent frequency, and half of the blind splits were spiked with known concentrations of constituents to be analyzed in order to evaluate laboratory analytical recoveries. Reported results fall within quality assurance tolerance guidelines outlined in Table 3.

TABLE 3

Quality Assurance Tolerance Guidelines

Constituent	Recovery Range at Low Levels ($\mu g/L$)*	Acceptable Split/ Spike Recovery Range
Copper	1-20 +/- 5	> 20 70-130%
Chromium	1-20 +/- 5	> 20 70-130%
Lead	5-25 +/- 8	> 25 60-140%
Molybdenum	1	90-110%
Nickel	5-25 +/- 6	>25 65-135%
Selenium	0.4	90-110%
Zinc	1-20 +/- 6	> 20 70-130%
Boron	50	85-115%
Chloride	5000	85-115%

* For certain constituents, recovery is expressed as an absolute value rather than a percentage at low levels. For example, if the result of copper analysis for a particular sample is 10 $\mu g/L$, a duplicate analysis must fall between 5 $\mu g/L$ and 15 $\mu g/L$. If the sample is greater than 20 $\mu g/L$, recovery is expressed as a percent and must be between 70 and 130%. If a recovery range is not shown at low levels, the detection limit is given.

Load Calculations

The loads and flow weighted concentrations were calculated and combined for selenium, boron and salt for Mud Slough (north) and Salt Slough as well as for all the inflow drains. Loads for selenium and boron were calculated in pounds and salt was calculated in tons. The flow weighted concentrations for salt and boron were calculated in units of mg/L and selenium was calculated in units of g/L. The inflow drains used in the load calculations were the following: Firebaugh Main Drain (includes Broadview WD, Central California ID, Firebaugh WD), Panoche Drain, Charleston Drain and Hamburg Drain (Pacheco WD). The total load from the drains were the summation of Main, Panoche, Charleston, and Hamburg drain loads minus the drainage water recirculated with Central California Irrigation District (CCID) supply water. A portion of the drain water mixed into CCID's supply canal is also routed to the Camp 13 ditch; therefore, when the drain water is mixed into CCID's supply canal, its quality can be assumed to be the same as the drain water in Camp 13 ditch.

Detailed methodologies for the load calculations can be found in Karkoski and Tucker, 1993, Karkoski, 1994, and Grober et al., 1996 (draft).

WATER YEAR 1995 HYDROLOGY

During WY 95, 73% of the total precipitation fell from January to March. This rainfall pattern is common, but the heavy precipitation that fell during March is unusual. Compared to the 1990-1995 historical record, the month of March 1995 had the highest total precipitation. The rainfall during March 1995 was 4.53 inches, with most of the months precipitation occurring between the 9th and 11th (3.19 inches).

During WY 95, releases from the Friant and McSwain dams were much higher than normal and Kings River water flowed north through the Fresno Slough for the first time since 1986 (Ed Dittenbir, Kings River Water Association, personal communication, 1996). A total of 6,637 acre-feet flowed from the Kings River through the Fresno Slough to the Mendota Pool from 15 to 29 March, 1995. Water from the Mendota Pool can enter the San Joaquin River upstream of Lander Avenue. Friant Dam creates the Millerton Lake Reservoir, and controls flows in the San Joaquin River upstream of the study area. Friant Dam flood control releases began on 13 February and ended on 5 August, 1995. The peak flood release from Friant occurred on 13 March, with 15,997 acre-feet released to the San Joaquin River.

McSwain Dam is a coffer dam below the New Exchequer Dam, that creates the Lake McClure Reservoir. Both dams control flows on the Merced River, that flows into the San Joaquin River downstream of the Hills Ferry sampling site. The peak release period for McSwain dam occurred from 25 to 31 March, with a total of 7,932 acre-feet. McSwain Dam was actually overtopped during the spring of 1995, and released water via the

Daily flow rates for the San Joaquin River at Patterson and Vernalis are depicted in Figure 3. Peak flow rates occurred during January and from March-July. The impact of heavy precipitation, and flood control releases from various reservoirs is reflected in the increased flow in the San Joaquin River during WY 95. Total discharge flows for March at Vernalis and Patterson topped 50,000 acre-feet and 30,000 acre-feet, respectively.

Mud Slough (north) and Salt Slough are the main waterways that drain the Grasslands area on the west side of the San Joaquin River. Flows in both sloughs peaked during March, and contributed a combined total of 263,769 acre-feet to the river upstream of Hills Ferry during WY 95. Land use in the Grasslands area is a combination of irrigated agriculture and wetland habitat.

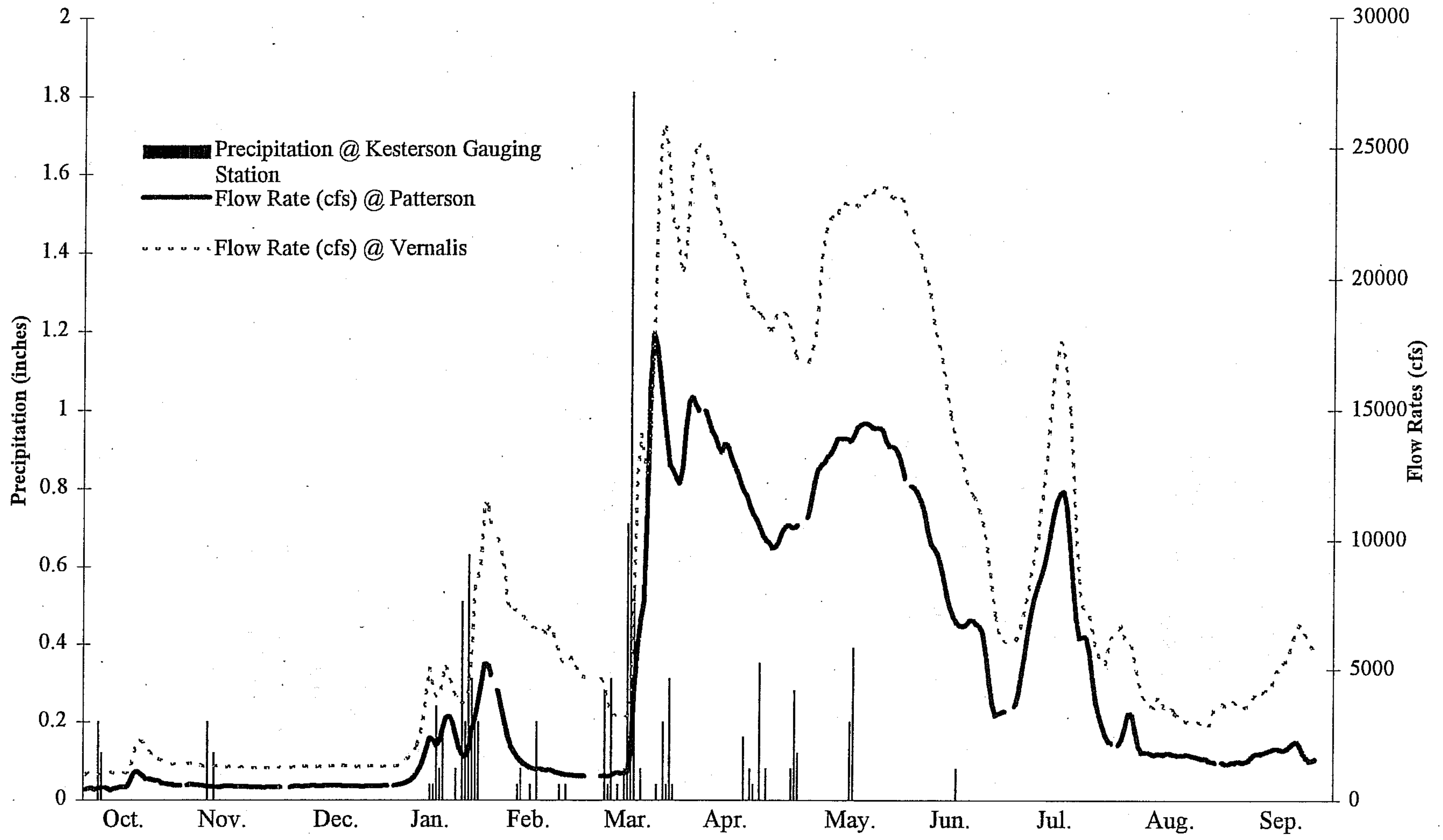
Seasonal flooding of wetlands and extremely heavy precipitation during the winter of 1995 caused elevated ground water levels along the lower reaches of the San Luis Drain. The groundwater infiltrated into the drain, causing water levels to rise close to the top of the concrete lining. Heavy precipitation during March caused flood flows to overtop the San Luis Drain (a concrete channel that formerly carried subsurface agricultural discharge to Kesterson Reservoir). Surface flood water entered the Drain near Kamm Avenue in Fresno County during March 1995. This flood water forced emergency releases from the Drain terminus to Mud Slough (north) in Merced County. Discharges from the San Luis Drain to Mud Slough (north) occurred from 15 March through 29 March 1995.

RESULTS

Following the trend found in other WYs, the highest concentrations of the measured constituents was found at the inflow monitoring stations near the southern boundary of the Grassland Area. The internal flow stations that carried supply water had the lowest measured constituent concentrations. Constituent concentrations at outflow monitoring stations varied depending on whether the channel was carrying subsurface drainage from the Drainage Problem Area (DPA). Water quality analysis results at the inflow, internal flow, and outflow monitoring stations will be discussed separately.

Water quality results for both minerals and trace elements are listed by site in Appendices A through C; Grassland inflows (Appendix A), internal flows (Appendix B), and outflows (Appendix C). Appendix D contains water quality data collected by the Regional Board at the San Luis Drain terminus. The ranges, mean and median values for each measured constituent at each site are shown in these appendices. For this study, EC represented relative salinity; while boron, chloride, and sulfate were the primary mineral constituents of concern. The median mineral, trace element and hardness values for WY 95 are listed in Table 4 for each monitoring station. The median values are tabulated for WY 95 and previous water years in Table 5.

Figure-3
Precipitation vs. Flow Rates at Select Sites Along the San Joaquin River: WY 95



Minerals

Inflow Monitoring Stations:

The inflow monitoring stations represent the quality of water entering the Grassland Area. The first eight monitoring stations (I-l, I-2, I-4, I-6 to I-10) listed in Table 4 represent the inflow to the South Grassland Area. The other two inflow stations (I-11 and I-12) either discharge to sloughs or the North Grassland Area (Figure 2).

Continuing the trend found in previous WYs, the inflows that carry a substantial portion of subsurface drainage water, Main (Firebaugh) (I-l), Panoche (I-2), Hamburg (I-6), and Charleston Drains (I-8), had elevated salinity levels. Hamburg Drain had the highest median EC (4,850 μmhos/cm), chloride (680 mg/L), hardness (1,600 mg/L) and sulfate (1,500 mg/L) values. Panoche Drain had the highest median boron (7.6 mg/L) value.

Internal Flow Monitoring Stations:

Two internal flow sites, the San Luis Spillway and the CCID Main were monitored during the fall wetland flooding period, and monthly thereafter. These channels are the major supply sources of water for duck hunting clubs. Salinity and boron concentrations remained relatively low in the channels. Median EC was 907 and 301 μmhos/cm for the Spillway and CCID Main, respectively, while median boron concentrations were 0.56 and 0.25 mg/L, respectively.

Outflow Monitoring Stations:

All of the outflow sites had elevated levels of salinity and minerals (Table 4). Mud Slough (north) at the San Luis Drain (0-2A) and Salt Slough at Lander (0-4) are both located near continuous flow meters making them valuable stations to determine constituent loads leaving the Grasslands Area. All available mineral information for the outflow sites during WY 95 has been tabulated in Appendix C.

During WY 95, Mud Slough (north) near the San Luis Drain had EC values ranging from 616 to 4,600 μmhos/cm with a median of 1,570 μmhos/cm. Boron at this site ranged from 0.4 to 2.7 mg/L with a median value of 1.1 mg/L.

Salt Slough had EC values ranging from 1,450 to 3,550 μmhos/cm with a median value of 2,070 μmhos/cm. Boron concentrations in Salt Slough ranged from 0.7 to 4.0 mg/L with a median of 2.2 mg/L.

Trace Elements

Although selenium was monitored at every site, analyses of molybdenum and additional trace elements was limited because of the overall low concentrations found during previous surveys.

Table 4. Median Constituent Concentrations for Waterways throughout the Grassland Watershed: WY95

Type	Station	EC (umhos/cm)	B	Cl	SO4	Se	Mo	Cr	Cu	Ni	Pb	Zn	Hardness mg/L
			mg/L			ug/L							
I-1	Main (Firebaugh) Drain	3710	4.2	385	1300	65	23	15	7	17	<5	24	695
I-2	Panoche Drain	4640	7.6	580	1400	84	11	19	1	8	<5	13	1100
I-4	Agatha Canal	1520	0.6	290	710	4.4	3	*	*	*	*	*	600
I-6	Hamburg Drain	4850	5.3	680	1500	70	6	14	<1	5	<5	9	1600
I-7	Camp 13	2780	2.6	325	860	32	11	*	*	*	*	*	420
I-8	Charleston Drain	4500	4.0	470	1050	63	4	16	6	15	<5	22	970
I-9	Almond Drain	610	0.32	115	96	1.7	*	*	*	*	*	*	140
I-10	Rice Drain	2640	3.9	295	670	2.4	11	*	*	*	*	*	500
I-11	Boundary Drain	1500	0.63	380	260	0.6	*	*	*	*	*	*	400
I-12	Salt Slough @ Hereford	740	0.20	116	80	0.7	6	*	*	*	*	*	220
T	San Luis Canal @ Highway 152	809	0.35	120	110	1.8	*	*	*	*	*	*	170
T-1	CCID Main Canal	301	0.25	98	67	1.4	*	*	*	*	*	*	130
T-5	Santa Fe Canal @ Henry Miller Rd.	712	0.35	72	100	1.5	*	*	*	*	*	*	140
T-7A	San Luis Canal @ Henry Miller Rd.	728	0.43	94	103	2.2	*	*	*	*	*	*	140
T-14	San Luis Spillway Ditch @ Santa Fe Grade	907	0.56	130	96	0.6	*	*	*	*	*	*	180
T-13	Porter-Blake Bypass	3040	4.0	345	940	40	8	*	*	*	*	*	790
O-4	Salt Slough @ Lander	2070	2.2	330	490	17	9	10	7	8	<5	32	500
O-1	Mud Slough @ Newman Gun Club	1550	1.1	240	260	1.0	*	5	3	5	14	7	290
O-3	Los Banos Creek	1000	0.57	160	100	0.6	*	*	*	*	*	*	210
O-2	Mud Slough @ San Luis Drain	1570	1.1	220	200	1.0	6	24	9	22	<5	19	310
SLD	San Luis Drain @ Highway 152	7780	15	770	3300	3.7	57	<1	<1	8	<5	<1	2400

* Samples not analyzed for particular trace element

I = Inflow O = Outflow
T = Internal flow

Table 5.

Median Constituent Concentrations for Grassland Area Canals & Streams: Water Years 1985-1995.

(Data for WY's 85, 86, and 87 from James et al., 1988; for WY 88 from Chilcott et. al., 1989; for WY's 89, 90, and 91 from Westcot et al., 1990, 1991,1992; for WY 92 from Karkoski and Tucker 1993; for WY 93 from Chilcott et.al., 1995; and for WY 94 , Vargas et. al., 1995).

Map ID	Monitoring Site / Water Year	EC	B	Cl	SO4	Se	Mo	Cr	Cu	Ni	Pb	Zn	Hardness
		Median Constituent Concentrations											
		µmhos/cm	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L
I-1	Main (Firebaugh) Drain @ Russell												
	Dry WY 85	2400	3.2	230	693	35	–	–	–	–	–	–	–
	Wet WY 86	2700	3.5	250	900	46	14	16	9	27	–	14	–
	Critical WY 87	2600	3.4	270	630	42	9	19	9	22	–	28	–
	Critical WY 88	3000	3.6	320	790	49	10	22	12	22	<5	29	–
	Critical WY 89	2980	3.9	315	835	49	13	17	9	19	<5	23	–
	Critical WY 90	3400	4.6	370	1200	52	24	10	5	11	<5	13	–
	Critical WY 91	3450	4.6	440	1400	52	21	10	23	<5	21	18	940
	Critical WY 92	3700	5.2	319	849	59	28	14	8	17	<5	18	640
	Above Normal WY 93	3530	5.1	342	972	52	19	27	14	24	<5	34	834
	Critical WY 94	3550	4.5	455	1235	61	29	24	12	33	<5	26	889
	Wet WY 95	3710	4.2	385	1300	65	23	15	7	17	<5	24	695
I-2	Panoche Drain/O'Banion												
	Dry WY 85	3500	6.5	460	985	38	3	–	–	–	–	–	–
	Wet WY 86	3400	5.8	390	800	56	6	26	6	15	–	15	–
	Critical WY 87	4375	7.8	550	1075	47	3	40	10	13	–	18	–
	Critical WY 88	3650	6.4	440	890	54	3	43	12	21	<5	29	–
	Critical WY 89	4180	6.5	520	1000	69	6	32	5	8	<5	11	–
	Critical WY 90	4550	7.5	665	1400	72	8	32	4	9	<5	10	–
	Critical WY 91	4450	7.5	620	1300	64	8	3	20	<5	7	7	1200
	Critical WY 92	4870	8.0	655	1490	82	11	16	3	<5	<5	6	1200
	Above Normal WY 93	4800	7.7	620	1280	76	11	38	10	15	<5	11	1170
	Critical WY 94	4840	8.0	624	1320	88	10	38	7	16	<5	8	1124
	Wet WY 95	4640	7.6	580	1400	84	11	19	1	8	<5	13	1100
I-4	Agatha Canal*												
	Dry WY 85	2600	4.9	315	1100	26	1	–	–	–	–	–	–
	Wet WY 86	3300	5.6	400	900	44	<5	13	9	21	–	16	–
	Critical WY 87	3305	5.6	410	760	38	6	22	7	12	–	12	–
	Critical WY 88	3550	5.6	430	895	39	3	–	–	–	–	–	–
	Critical WY 89	880	0.36	130	100	2.9	2	–	–	–	–	–	–
	Critical WY 90	4040	6.6	480	1100	26	8	–	–	–	–	–	–
	Critical WY 91	4295	6.6	515	1100	53	9	–	–	–	–	–	1030
	Critical WY 92	3440	5.6	378	726	31	9	–	–	–	–	–	619
	Above Normal WY 93	3165	5.4	426	1045	23	8	–	11	–	–	–	855
	Critical WY 94	3570	5.9	468	1070	14	13	–	6	–	–	–	808
	Wet WY 95	1520	0.64	290	710	4.4	3	–	–	–	–	–	600

* Not sampled during November 1992

Table 5 continued:

Map ID	Monitoring Site / Water Year	EC	B	Cl	SO4	Se	Mo	Cr	Cu	Ni	Pb	Zn	Hardness
		Median Constituent Concentrations											
		µmhos/cm	mg/L			µg/L							mg/L
I-6	Hamburg Drain												
	Dry WY 85	3200	3.8	435	900	47	6	–	–	–	–	–	–
	Wet WY 86	3250	4.0	400	1000	51	4	13	5	10	–	13	–
	Critical WY 87	3345	3.7	420	925	58	<5	17	5	8	–	10	–
	Critical WY 88	3600	4.1	450	1050	56	5	11	5	<5	<5	6	–
	Critical WY 89	5120	5.7	660	1500	95	5	16	2	<5	<5	6	–
	Critical WY 90	4740	5.4	720	1400	84	5	14	1	<5	<5	6	–
	Critical WY 91	5540	5.6	730	1675	99	7	1	11	1	<5	<5	1650
	Critical WY 92	5090	5.2	725	1580	86	9	20	9	13	<5	18	1650
	Above Normal WY 93	5020	6.3	723	1515	76	9	25	7	13	<5	23	1630
	Critical WY 94	5320	5.9	742	1650	88	7	20	7	15	<5	6	1655
	Wet WY 95	4850	5.3	680	1500	70	6	14	<1	5	<5	9	1600
I-7	Camp 13 Slough												
	Dry WY 85	2550	3.4	280	745	32	4	–	–	–	–	–	–
	Wet WY 86	2950	3.9	375	905	43	<5	14	7	20	–	16	–
	Critical WY 87	2650	3.7	280	590	43	6	30	11	13	–	19	–
	Critical WY 88	4400	6.2	500	1050	43	4	–	–	–	–	–	–
	Critical WY 89	3750	5.2	440	940	59	8	–	–	–	–	–	–
	Critical WY 90	3440	4.9	455	1010	54	9	–	–	–	–	–	–
	Critical WY 91	3960	5.5	560	1300	55	21	–	–	–	–	–	1200
	Critical WY 92	4130	5.5	492	1240	64	11	–	–	–	–	–	1100
	Above Normal WY 93	4020	6.2	414	997	56	10	–	11	–	–	–	939
	Critical WY 94	3960	5.8	513	1275	58	12	5	8	13	<5	6	866
	Wet WY 95	2780	2.6	325	860	32	11	–	–	–	–	–	420
I-8	Charleston Drain												
	Dry WY 85	3900	2.6	395	1275	48	–	–	–	–	–	–	–
	Wet WY 86	4500	4.7	510	1580	93	8	9	10	14	–	18	–
	Critical WY 87	3855	4.2	480	1035	79	2	32	12	22	–	50	–
	Critical WY 88	4450	4.5	520	1300	71	3	31	13	27	–	47	–
	Critical WY 89	4400	3.8	520	1400	66	3	25	12	17	<5	33	–
	Critical WY 90	4350	3.7	525	1400	69	6	14	3	8	<5	17	–
	Critical WY 91	4370	4.2	645	1700	60	8	3	10	<5	7	11	1600
	Critical WY 92	4283	4.3	609	1300	66	8	10	7	9	<5	21	1310
	Above Normal WY 93	4155	4.2	685	1450	70	8	15	7	14	<5	20	1590
	Critical WY 94	4540	4.0	582	1400	78	6	12	8	12	<5	15	1200
	Wet WY 95	4500	4.0	470	1050	63	4	16	6	15	<5	22	970
I-9	Almond Drive Drain												
	Dry WY 85	1520	1.6	160	340	2.0	–	–	–	–	–	–	–
	Wet WY 86	–	–	–	–	–	–	–	–	–	–	–	–
	Critical WY 87	1925	2.1	224	395	4.8	5	28	11	21	–	25	–
	Critical WY 88	2300	2.1	230	460	4.6	–	18	7	13	–	15	–
	Critical WY 89	2160	2.2	190	420	3.7	–	–	–	–	–	–	–
	Critical WY 90	1320	0.91	155	220	2.3	–	–	–	–	–	–	–
	Critical WY 91	1415	1.0	200	250	2.9	–	–	–	–	–	–	330
	Critical WY 92	1670	1.5	220	320	2.2	–	–	–	–	–	–	330
	Above Normal WY 93	900	0.40	123	119	1.9	9	–	–	–	–	–	187
	Critical WY 94	840	0.58	106	116	2.1	–	–	–	–	–	–	180
	Wet WY 95	610	0.32	115	96	1.7	–	–	–	–	–	–	140

Table 5 continued:

Map ID	Monitoring Site / Water Year	EC (µmhos/cm)	B (mg/L)	Cl (mg/L)	SO4 (mg/L)	Se (µg/L)	Mo (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	Hardness (mg/L)
		Median Constituent Concentrations											
I-10	Rice Drain												
	Dry WY 85	2450	5.7	245	715	2.5	–	–	–	–	–	–	–
	Wet WY 86	3300	8.1	350	1080	3.0	14	5	6	23	–	13	–
	Critical WY 87	2500	6.1	260	550	2.6	11	3	3	6	–	<1	–
	Critical WY 88	2790	5.1	310	700	2.6	15	–	–	–	–	–	–
	Critical WY 89	2745	5.4	280	673	3.1	14	–	–	–	–	–	–
	Critical WY 90	3050	5.4	350	855	2.7	16	–	–	–	–	–	–
	Critical WY 91	2640	4.7	420	1145	2.6	22	–	–	–	–	–	860
	Critical WY 92	3000	5.9	400	868	3.4	20	–	–	–	–	–	700
	Above Normal WY 93	2250	4.1	240	617	2.6	12	–	–	–	–	–	525
	Critical WY 94	2970	5.4	352	866	3.2	17	–	–	–	–	–	674
	Wet WY 95	2640	3.9	295	670	2.4	11	–	–	–	–	–	500
I-11	Boundary Drain												
	Dry WY 85	1090	0.45	195	135	1.0	–	–	–	–	–	–	–
	Wet WY 86	1710	0.65	250	210	1.0	6	2	7	9	–	14	–
	Critical WY 87	1250	0.54	200	145	1.6	4	<1	2	<5	–	3	–
	Critical WY 88	1470	0.50	230	180	1.4	6	–	–	–	–	–	–
	Critical WY 89	1435	0.53	240	190	1.0	–	–	–	–	–	–	–
	Critical WY 90	1500	0.44	250	175	0.9	–	–	–	–	–	–	–
	Critical WY 91	1420	0.44	233	175	0.8	–	–	–	–	–	–	280
	Critical WY 92	1330	0.48	237	164	0.8	–	–	–	–	–	–	290
	Above Normal WY 93	1040	0.49	177	126	1.1	–	–	–	–	–	–	232
	Critical WY 94	1660	0.65	301	223	1.1	–	–	–	–	–	–	327
	Wet WY 95	1500	0.63	380	260	0.6	–	–	–	–	–	–	400
I-12	Salt Slough @ Hereford												
	Dry WY 85	850	0.37	120	100	1.0	–	–	–	–	–	–	–
	Wet WY 86	785	0.33	100	99	1.0	<5	3	5	9	–	22	–
	Critical WY 87	1000	0.39	130	120	1.4	3	1	2	<5	–	2	–
	Critical WY 88	1150	0.38	160	140	1.2	5	–	–	–	–	–	–
	Critical WY 89	1070	0.36	160	140	1.2	–	–	–	–	–	–	–
	Critical WY 90	1030	0.30	160	110	0.6	–	–	–	–	–	–	–
	Critical WY 91	1045	0.30	180	130	0.9	–	–	–	–	–	–	260
	Critical WY 92	1140	0.37	180	125	1.0	–	–	–	–	–	–	285
	Above Normal WY 93	1060	0.35	149	120	0.8	–	–	6	–	–	–	214
	Critical WY 94	1020	0.33	168	138	0.8	–	–	7	–	–	–	216
	Wet WY 95	740	0.20	116	80	0.7	6	–	–	–	–	–	220
T-1	CCID Main Canal												
	Dry WY 85	430	0.21	72	35	<1	–	–	–	–	–	–	–
	Wet WY 86	385	0.21	53	47	1.3	<5	3	3	5	–	8	–
	Critical WY 87	570	0.28	65	58	2.2	<5	1	3	<5	–	3	–
	Critical WY 88	760	0.29	120	65	1.7	–	–	–	–	–	–	–
	Critical WY 89	700	0.26	94	68	1.7	–	–	–	–	–	–	–
	Critical WY 90	680	0.32	120	93	2.3	–	–	–	–	–	–	–
	Critical WY 91	710	0.27	135	86	1.5	–	–	–	–	–	–	150
	Critical WY 92	800	0.38	130	110	2.0	–	–	–	–	–	–	170
	Above Normal WY 93	820	0.35	77	83	1.4	–	–	11	–	–	–	155
	Critical WY 94	670	0.37	92	102	1.7	–	–	6	–	–	–	142
	Wet WY 95	301	0.25	98	67	1.4	–	–	–	–	–	–	130

Table 5 continued:

Map ID	Monitoring Site / Water Year	EC	B	Cl	SO4	Se	Mo	Cr	Cu	Ni	Pb	Zn	Hardness
		Median Constituent Concentrations											
		µmhos/cm	mg/L			µg/L							mg/L
T-5	Santa Fe Canal @ Henry Miller Road												
	Above Normal WY 93	1208	1.2	150	171	5.3	4	--	--	--	--	--	288
	Critical WY 94	900	0.63	135	174	1.8	--	--	--	--	--	--	221
	Wet WY 95	712	0.35	72	100	1.5	--	--	--	--	--	--	140
T-7	San Luis Canal/Hwy 152												
	Dry WY 85	1550	1.4	180	295	4.5	--	--	--	--	--	--	--
	Wet WY 86	1200	1.4	130	200	2.0	<5	4	4	10	--	9	--
	Critical WY 87	2630	3.4	260	520	4.0	<5	3	3	<5	--	7	--
	Critical WY 88	2550	3.6	280	570	3.9	--	--	--	--	<5	--	--
	Critical WY 89	1045	0.76	135	140	2.5	--	--	--	--	--	--	--
	Critical WY 90	1400	1.7	180	270	2.5	--	--	--	--	--	--	--
	Critical WY 91	1625	1.6	260	455	2.6	--	--	--	--	--	--	520
	Critical WY 92	1030	0.60	170	240	1.7	--	--	--	--	--	--	270
	Above Normal WY 93	878	0.53	134	116	2.1	--	--	--	--	--	--	209
	Critical WY 94	935	0.62	118	131	1.7	--	--	--	--	--	--	191
	Wet WY 95	809	0.35	120	110	1.8	--	--	--	--	--	--	170
T-7A	San Luis Canal @ Henry Miller Road												
	Above Normal WY 93	1730	2.2	198	345	12	--	--	--	--	--	--	402
	Critical WY 94	980	0.8	130	184	2.5	--	--	--	--	--	--	222
	Wet WY 95	728	0.4	94	103	2.2	--	--	--	--	--	--	140
T-13	Porter Blake Bypass												
	Above Normal WY 93	3360	5.2	351	832	46	--	--	--	--	--	--	777
	Critical WY 94	3160	4.9	400	897	44	--	--	--	--	--	--	700
	Wet WY 95	3040	4.0	345	940	40	8	--	--	--	--	--	790
T-14	San Luis Spillway Ditch @ Santa Fe Grade												
	Above Normal WY 93	778	0.37	155	80.4	0.3	--	--	5	--	--	--	216
	Critical WY 94	820	0.52	132	110	0.6	--	--	7	--	--	--	170
	Wet WY 95	907	0.56	130	96	0.6	--	--	--	--	--	--	180
O-1	Mud Slough @ NGC												
	Dry WY 85	-	--	--	--	--	--	--	--	--	--	--	--
	Wet WY 86	1800	2.0	215	330	4.0	5	9	5	11	--	15	--
	Critical WY 87	2600	2.4	300	420	5.1	13	7	4	10	--	1	--
	Critical WY 88	2480	2.2	330	440	4.7	--	--	--	--	--	--	--
	Critical WY 89	2310	1.7	325	385	2.1	--	--	--	--	--	--	--
	Critical WY 90	2480	2.1	335	510	4.3	10	--	--	--	--	--	--
	Critical WY 91	3540	3.2	540	905	3.9	15	--	--	--	--	--	780
	Critical WY 92	3130	2.6	450	663	2.3	--	--	--	--	--	--	605
	Above Normal WY 93	1980	1.5	382	558	3.0	9	6	2	<5	<5	4	509
	Critical WY 94	1605	1.2	230	260	1.1	--	6	4	7	<5	7	319
	Wet WY 95	1550	1.1	240	260	1.0	--	5	3	5	14	7	290

Table 5 continued:

Map ID	Monitoring Site / Water Year	EC µmhos/cm	B mg/L	Cl mg/L	SO4 mg/L	Se µg/L	Mo µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	Hardness mg/L
		Median Constituent Concentrations											
O-2A	Mud Slough @ SLD												
	Dry WY 85	2600	3.1	305	525	13	--	--	--	--	--	--	--
	Wet WY 86	2300	3.0	280	630	8.5	8	6	5	14	--	11	--
	Critical WY 87	2600	3.0	320	540	17	9	12	9	11	--	7	--
	Critical WY 88	2820	2.7	350	510	9.3	11	--	--	--	--	--	--
	Critical WY 89	3000	2.4	425	480	2.1	11	10	4	<5	12	12	--
	Critical WY 90	3060	3.4	410	590	5.2	12	6	2	8	<5	7	--
	Critical WY 91	4030	4.4	640	1000	2.4	27	3	5	<5	6	5	820
	Critical WY 92	3130	2.5	460	660	1.5	22	6	4	10	<5	8	630
	Above Normal WY 93	2495	1.9	343	491	2.0	9	12	5	10	<5	9	454
	Critical WY 94	2560	1.9	526	732	1.0	9	7	4	8	<5	5	420
	Wet WY 95	1570	1.1	220	200	1.0	7	24	9	22	<5	19	310
O-3	Los Banos Ck/HWY 140												
	Dry WY 85	--	--	--	--	--	--	--	--	--	--	--	--
	Wet WY 86	2200	2.3	430	300	1.0	<5	6	8	18	--	17	--
	Critical WY 87	1855	1.6	215	215	1.4	--	--	--	--	--	--	--
	Critical WY 88	1690	1.2	230	210	1.1	--	--	--	--	--	--	--
	Critical WY 89	1630	1.0	240	200	0.9	--	--	--	--	--	--	--
	Critical WY 90	1870	1.2	210	290	0.8	--	--	--	--	--	--	--
	Critical WY 91	2745	1.6	490	495	1.0	14	--	--	--	--	--	605
	Critical WY 92	1500	1.4	--	--	1.1	--	--	--	--	--	--	400
	Above Normal WY 93	1478	1.3	182	193	1.0	--	--	--	--	--	--	280
	Critical WY 94	1530	0.91	228	200	0.6	--	--	--	--	--	--	295
	Wet WY 95	1000	0.57	160	100	0.6	--	--	--	--	--	--	210
O-4	Salt Slough @ Lander												
	Dry WY 85	1250	0.96	185	195	4.5	--	--	--	--	--	--	--
	Wet WY 86	1610	1.3	240	245	7.4	7	4	6	12	--	18	--
	Critical WY 87	1720	1.7	250	350	12	6	6	4	6	--	4	--
	Critical WY 88	1940	1.9	260	385	13	6	--	--	--	--	--	--
	Critical WY 89	2040	1.9	270	430	15	6	13	6	1	12	18	--
	Critical WY 90	2340	2.3	340	525	15	7	10	4	9	<5	15	--
	Critical WY 91	2460	2.0	335	370	15	11	2	3	<5	<5	5	460
	Critical WY 92	2420	2.1	400	445	13	11	6	3	8	<5	8	590
	Above Normal WY 93	2270	2.5	327	385	18	9	13	6	11	<5	13	470
	Critical WY 94	2510	2.5	395	578	20	9	10	7	11	<5	11	410
	Wet WY 95	2070	2.2	330	490	17	9	10	7	8	<5	32	500
SLD	San Luis Drain @ Hwy 152												
	Wet WY 95	7780	15	770	3300	3.7	57	<1	<1	8	<5	<1	2400

Total recoverable selenium, molybdenum, copper, chromium, lead, nickel, and zinc are listed in Appendices A through C for selected inflow, internal flow, and outflow monitoring stations. The ranges, mean and median concentrations of the trace elements measured at each station are also listed in these appendices. The median trace element concentrations at each station for WY 95 are tabulated in Table 4.

Inflow Monitoring Stations:

The highest median trace element concentrations occurred at the South Grassland inflow stations (I-l, I-2, I-4, and I-6 to I-10), where the median selenium values ranged from 1.7 μg/L at Almond Drain (I-9) to 84 μg/L at Panoche Drain (I-2). The Main (I-l), Panoche (I-2), Hamburg (I-6), Camp 13 (I-7) and Charleston (I-8) Drains all had median selenium concentrations greater than 30 μg/L. As with salinity and boron, the selenium concentrations vary depending on the amount of dilution available from irrigation return flows and the quality of the tile water in the drain at the time of sampling. Selenium concentrations in excess of 100 μg/L were found at the Hamburg Drain (7% of the measurements), Panoche Drain (25% of the measurements), Main Drain (29% of the measurements), and Charleston Drain (12% of the measurements). No particular pattern was observed in selenium distributions in the drains with respect to time, except that the lowest concentrations occurred in the fall and elevated selenium concentrations were generally observed in the spring. There is a lull in irrigation activities in the fall and a peak in the late winter and early spring with pre-planting irrigations.

As has been observed in previous WYs, inflow sites that convey drainage originating from Sierra Nevada sedimentary deposits (Rice Drain, Boundary Drain, and Salt Slough Ditch at Hereford Road) contain the lowest median selenium concentrations. Median selenium concentrations for these sites were less than 2.4 μg/L.

Although monitoring of molybdenum was limited, the highest median value was observed in the Main Drain (23 μg/L). The Rice, Panoche, and Camp 13 drains all had a median molybdenum concentration of 11 μg/L. The remaining inflow drains had median molybdenum concentrations ranging from 4 to 6 μg/L.

In addition to selenium and molybdenum, copper, chromium, nickel, lead, and zinc were monitored at the four major subsurface drainage inflows (Main, Panoche, Hamburg and Charleston Drains). Based on the extreme hardness of the water from the inflow stations (median levels ranging from 700 mg/L to 1600 mg/L), toxicity from copper, nickel, lead, and zinc is not expected (Marshack, 1995). Median total recoverable chromium values were greater than the chronic toxicity value for hexavalent chromium (11 μg/L) during WY 95, with total chromium median values ranging from 14 to 19 μg/L. Since analyses did not include evaluation of the various chromium species, it is not known whether hexavalent chromium concentrations are high enough to cause toxicity.

Internal Flow Monitoring Stations:

The internal flow sites are monitored to track the path of subsurface drainage from irrigated lands as it moves through the Grassland conveyance system and to track the quality of water in wetland supply channels. Elevated selenium concentrations are indicative of the presence of subsurface drainage water, as the subsurface drainage is the principal source of selenium. The Porter-Blake Bypass is used to route flows from the South Grassland Area to Salt Slough. Elevated selenium concentrations were found almost year round in the Porter-Blake Bypass with the exception of the first two weeks in October. Concentrations ranged from 1.7 to 69 μg/L with a median of 40 μg/L. Using the elevated selenium concentrations as an indicator, it appears that subsurface drainage from the DPA was continuously routed to Salt Slough during WY 95, except for the first two weeks in October.

Elevated selenium concentrations (16 to 61 μg/L) were found in the San Luis Canal at Henry Miller Road from late January to late March. Selenium concentrations were generally below 5.4 μg/L at other times of WY 95. Flows from the Santa Fe Canal can be discharged to Salt Slough via the City Gates diversion or, when the diversion is closed, flows can be routed to Mud Slough (north). Flows in excess of the Porter-Blake Bypass' capacity may also be diverted into these channels during peak flow periods such as in February and March.

The San Luis Spillway Ditch and the CCID Main Canal were monitored during part of the wetland flooding period, and monthly thereafter. These channels provide supply water for the local wetlands and originate from the Delta-Mendota Canal. The maximum selenium concentration measured in the San Luis Spillway during WY 95 was 0.8 μg/L. In the CCID Main Canal, selenium concentrations ranged from 0.6 to 3.8 μg/L; however, selenium concentrations remained below 2 μg/L during the wetland flooding period in October. Similar concentrations of selenium were also observed in the San Luis Canal at Highway 152 (0.8 to 10 μg/L). This site normally contains water originating from the Delta-Mendota Canal.

Outflow Monitoring Stations:

The outflow monitoring stations, as mentioned earlier, are located on two tributaries of the San Joaquin River; Salt Slough (site 0-4) and Mud Slough (north), (sites 0-1 through 0-3) as described in Table 1.

Selenium was monitored at all four outflow stations, while molybdenum, copper, chromium, nickel, lead, and zinc were monitored quarterly at three stations (0-1, 0-2A and 0-4). The median trace element concentrations detected during this study are provided in Table 4.

At monitoring station 0-4 (Salt Slough at Lander Avenue), selenium concentrations ranged from 0.8 to 38 μg/L with a median of 17 μg/L. Selenium concentrations in Mud Slough (north) at the San Luis Drain (0-2A) ranged from 0.4 to 17 μg/L with a median of 1.0 μg/L. Los Banos Creek flows into Mud Slough (north) downstream of the Mud Slough (north) monitoring station near the San Luis Drain. The creek, along with any groundwater seepage, can dilute the constituent concentrations within Mud Slough (north) as measured at the Newman Land and Cattle

Company station (0-1). Los Banos Creek receives its flow from the western portion of the North Grassland Area and from areas west of the study area. The creek receives little subsurface drainage. In WY 95, selenium concentrations ranged from 0.4 to 2.2 μg/L with a median of 0.6 μg/L in Los Banos Creek at Highway 140 (0-3). The downstream Mud Slough (north) station (0-1) had selenium concentrations similar to those found in the slough upstream of Los Banos Creek.

Flood induced discharges from the San Luis Drain to Mud Slough (north) occurred from 15 March through 29 March 1995. Selenium concentrations in the discharge were evaluated by the San Luis Delta Mendota Water Authority. The selenium concentration of the discharge effluent exceeded the Federal EPA standard of 5 μg/L 4-day average. However, data also indicated that the water quality of Mud Slough (north) up stream of the discharge, exceeded the Federal EPA standard during the flood event (San Luis and Delta Mendota Water Authority, 1995).

Molybdenum, copper, chromium, lead, nickel, and zinc were analyzed quarterly in Salt Slough at Lander Avenue and Mud Slough (north) at the San Luis Drain. Molybdenum concentrations in Salt Slough ranged from 7 to 14 μg/L, with a median concentration of 9 μg/L. Molybdenum concentrations in Mud Slough (north) ranged from 2 to 12 μg/L, with a median concentration of 6 μg/L.

As is the case with the inflow stations, concentrations recorded for copper, nickel, lead, and zinc would not be expected to cause toxicity due to the elevated hardness of the water in the sloughs (median levels ranging from 310 mg/L to 500 mg/L). Total recoverable chromium concentrations did exceed 11 μg/L (the chronic toxicity value of hexavalent chromium) in both sloughs, reaching a maximum of 37 μg/L in Mud Slough (north) and 23 μg/L in Salt Slough; however, hexavalent chromium was not measured directly.

LOADS

Between WYs 89 and 92, data shows that flow weighted concentrations from the drains entering the Grassland Area increased for boron, selenium and salt while the respective loads decreased (Karkoski et al, 1994). The trend toward lower loads in these drains was reversed in WY 93 (Chilcott et al., 1995). During WY 93, loads reached levels observed prior to the 1988 adoption of Basin Plan amendments to regulate subsurface drainage discharges. During WY 95, loads in the drains were elevated to the highest levels recorded since monitoring began in 1985 (Figures 4, 5, and 6). Water Year 95 is the third highest runoff year recorded in the San Joaquin River Basin since 1906. The leaching of accumulated salts built up in the soil profile may account for the load increase observed in 1995 when a comparison is made to the loads generated during the drought years.

The loads of boron and salt continue to be higher in Mud Slough (north) and Salt Slough than those from the drains; whereas, the selenium load from Mud Slough (north) and Salt Slough remains lower than those from the drains (except WY 90). Salt and boron are ubiquitous throughout the Grassland watershed. Selenium, in contrast, is primarily found in the subsurface drainage problem area that generates the drainage water that is discharged into the Grassland Area. As the two major drainage arteries for the entire watershed, Mud Slough (north) and Salt Slough transport the majority of drainage water to the San Joaquin River, with most being transported through Salt Slough in WY 95. While the total salt and boron loads can be expected to be higher from the overall watershed than just the drainage problem area, the decrease in selenium loads between the discharge into the Grassland Area and the San Joaquin River (Figure 6) remains unexplained. The U.S. Bureau of Reclamation is continuing to study potential mechanisms involved in a selenium sink as discussed in Karkoski and Tucker (1993).

DISCUSSION

For the purpose of illustrating changes in water quality in the Grassland Area waterways in WY 95, data for WY 95 was compared to WYs 93 and 94. Water Year 93 was an above normal runoff year with flood flows in the river during March, April and July. Water Year 93 represented a break from drought conditions, as it was the first above normal runoff year after six consecutive critical water years. In WY 93 full allocations were restored to exchange contractors and federal contractors received 50% of their contract allocations. The drought resumed in WY 94 and it was classified as a critical runoff year. Water allocations were once again curtailed to 75% and 35% for exchange and federal contractors, respectively. Water Year 95, was the third highest runoff year in the San Joaquin River Basin since 1906 (DWR, 1996). Exchange and federal contractors received full water allocations.

The combined effects of previously reduced water supplies with improved on-farm irrigation practices followed by near full water allocations can be seen in Figures 4-6 and Table 6. Between WYs 89 and 92, large reductions in loads (i.e. 42% for selenium) occurred from the drainage problem area. At the same time, concentrations of constituents of concern (salt, selenium, and boron) increased (i.e. 27% for selenium) (Table 6). The increased concentrations were likely due to the reduced availability of better quality tail water that would have reduced the concentrations in the drainage water. The reduction in tail water results from improved irrigation management and less water deliveries. The trend toward reduced loads was reversed in WY 93 with dramatic increases in loads over WY 92 (Figures 4-6). For example, there was a 75% and 63% increase in selenium and salt load, respectively, from the drainage problem area between WYs 92 and 93. This increase was attributed to improved water supplies and the increased leaching of salts (Chilcott et al. 1995).

Loads increased dramatically again in WY 95. Water Year 95 loads of boron and selenium were the highest on record since monitoring began in 1985. Water Year 95 total dissolved solid loads were superceded only by WYs 87-88. The increasing trend in the loads since WY 92 may be due to greater water usage by the drainers. Increased discharge which included both surface (tail water) and subsurface (tile water) drainage also occurred during WY 95. The discharge for WY 95 was 6% more than that generated in WY 89, and the selenium load was 22% more than WY 89 (Table 6). Water year 1989 is the first year after the Regional board adoped water quality objectives in the 1988 San Joaquin River Basin Plan 5C.

Table 6
Annual Salt, Boron and Selenium Loads and Concentrations for the Sloughs and Drainage Service Area (DSA)
WYs- 1986-1993

Salt Loads and Concentrations								
Water Year	MS+SS Loads Tons	DSA Loads Tons	MS+SS % Change from WY 89	DSA % Change from WY 89	MS+SS Conc. mg/L	DSA Conc. mg/L	MS+SS % Change from WY 89	DSA % Change from WY 89
WY 1986	479,682	206,476	27%	5%	1,241	2,168	-5%	-19%
WY 1987	424,929	226,597	13%	15%	1,336	2,261	2%	-16%
WY 1988	441,079	231,348	17%	17%	1,407	2,604	7%	-3%
WY 1989	376,269	197,161	0%	0%	1,309	2,677	0%	0%
WY 1990	367,789	166,324	-2%	-15%	1,389	2,933	6%	10%
WY 1991	214,272	127,744	-43%	-35%	1,542	3,209	18%	20%
WY 1992	190,926	108,019	-49%	-45%	1,643	3,227	26%	21%
WY 1993	325,536	175,740	-13%	-11%	1,425	3,203	9%	20%
WY1994	366,826	163,723	-3%	-17%	1,470	3,169	12%	18%
WY1995	479,123	222,195	21%	11%	1,345	2,838	3%	6%

Boron Loads and Concentrations								
Water Year	MS+SS Loads Tons	DSA Loads Tons	MS+SS % Change from WY 89	DSA % Change from WY 89	MS+SS Conc. mg/L	DSA Conc. mg/L	MS+SS % Change from WY 89	DSA % Change from WY 89
WY 1986	1,368,000	733,000	20%	2%	1.8	3.8	-10%	-25%
WY 1987	1,265,000	872,000	13%	17%	2.0	4.4	0%	-14%
WY 1988	1,301,000	830,000	14%	11%	2.1	4.7	5%	-8%
WY 1989	1,139,000	748,000	0%	0%	2.0	5.1	0%	0%
WY 1990	1,121,000	680,000	-2%	-9%	2.1	6.0	5%	18%
WY 1991	612,000	548,000	-46%	-27%	2.2	6.9	10%	35%
WY 1992	522,000	443,000	-54%	-41%	2.2	6.6	10%	29%
WY1993	1,066,000	725,000	-6%	-3%	2.3	6.6	15%	29%
WY1994	1,116,000	638,000	-2%	-15%	2.2	6.2	10%	22%
WY1995	1,449,000	889,000	21%	16%	2	5.7	0%	11%

MS = Mud Slough (north)
SS = Salt Slough

Table-6 (cont'd)

Selenium Loads and Concentrations								
Water Year	MS+SS Loads Tons	DSA Loads Tons	MS+SS % Change from WY 89	DSA % Change from WY 89	MS+SS Conc. mg/L	DSA Conc. mg/L	MS+SS % Change from WY 89	DSA % Change from WY 89
WY 1986	6,638	9,722	-18%	10%	8.6	51	-39%	-15%
WY 1987	7,640	10,741	-6%	22%	12	54	-15%	-10%
WY 1988	8,130	10,097	0.4%	15%	13	57	-8%	-5%
WY 1989	8,099	8,814	0%	0%	14.1	60	0%	0%
WY 1990	7,719	7,485	-5%	-15%	14.6	66	4%	10%
WY 1991	3,899	5,992	-52%	-32%	14	75	-0.7%	25%
WY 1992	2,919	5,119	-64%	-42%	12.6	76	-11%	27%
WY1993	6,871	8,849	-15%	0.3%	15	81	-11%	35%
WY1994	7,980	8,511	-1%	-3.4%	16	82	13%	37%
WY1995	10,633	11,346	24%	22%	14.9	72	5%	17%

Annual Flow in Acre-Feet				
Water Year	MS+SS Flow (acre-ft)	DSA Flow (acre-ft)	MS+SS % Change from WY 89	DSA % Change from WY 89
WY 1986	284,316	70,069	34%	29%
WY 1987	233,843	73,725	11%	36%
WY 1988	230,843	65,342	9%	21%
WY 1989	211,393	54,178	0%	0%
WY 1990	194,656	41,718	-8%	-23%
WY 1991	102,162	30,039	-52%	-45%
WY 1992	85,428	24,621	-60%	-55%
WY1993	167,955	40,359	-21%	-26%
WY1994	183,546	40,359	-13%	-30%
WY1995	263,769	57,574	20%	6.0%

Figure-4
Annual Salt Loads and Concentrations for Drains and Sloughs:
WYs 86-95

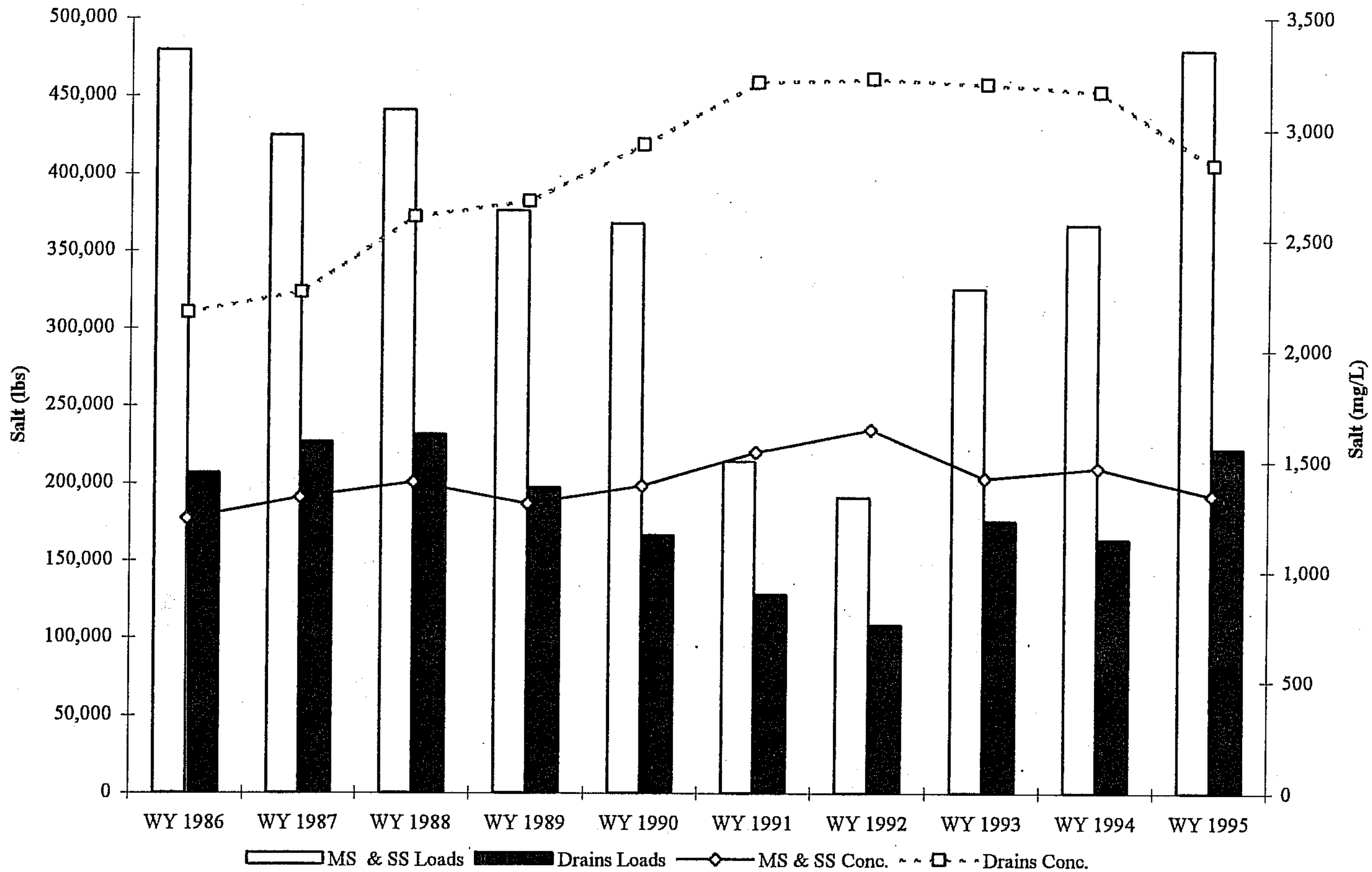


Figure-5

Annual Boron Loads and Concentrations for Drains and Sloughs: WYs 86-95

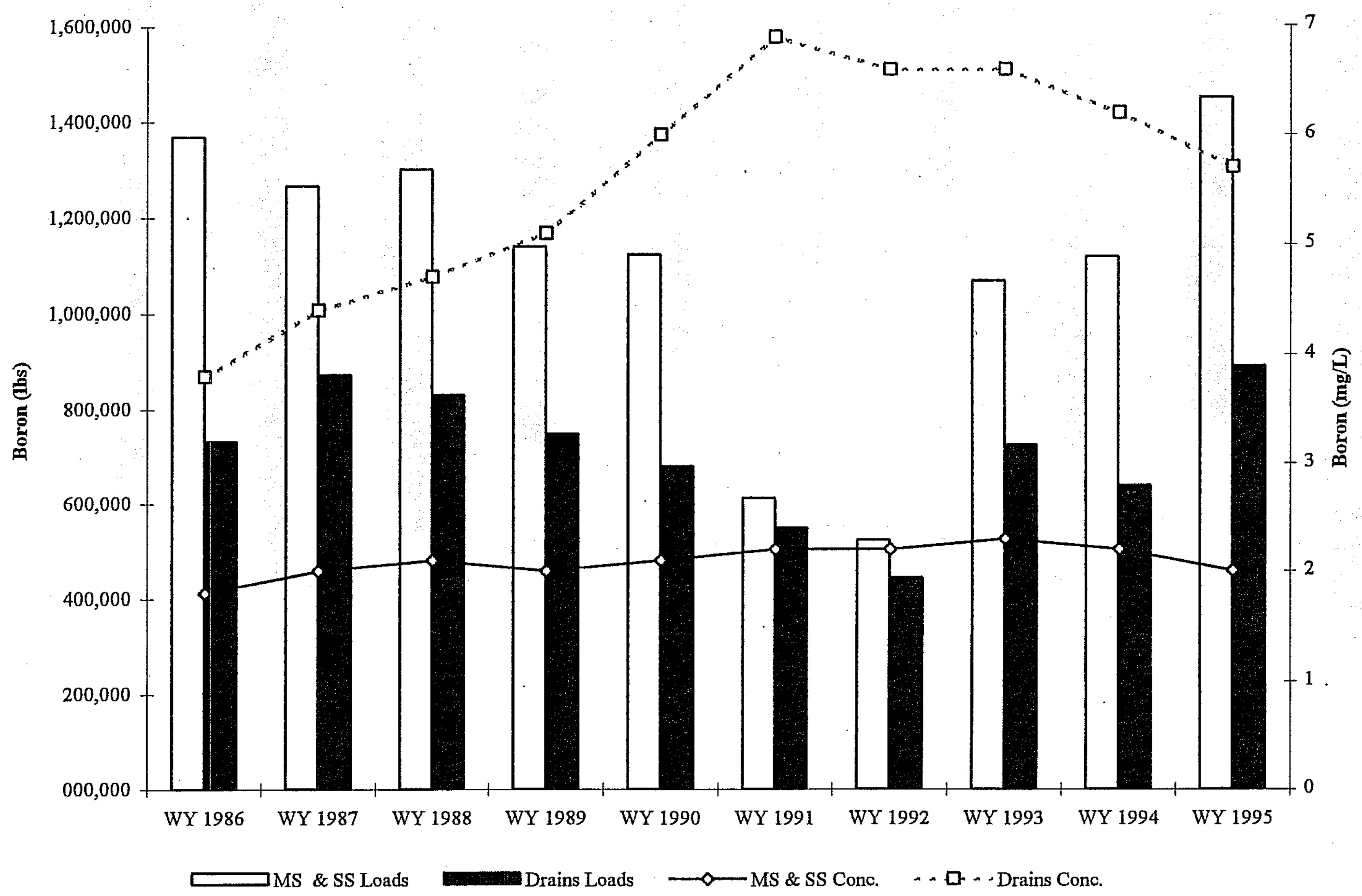
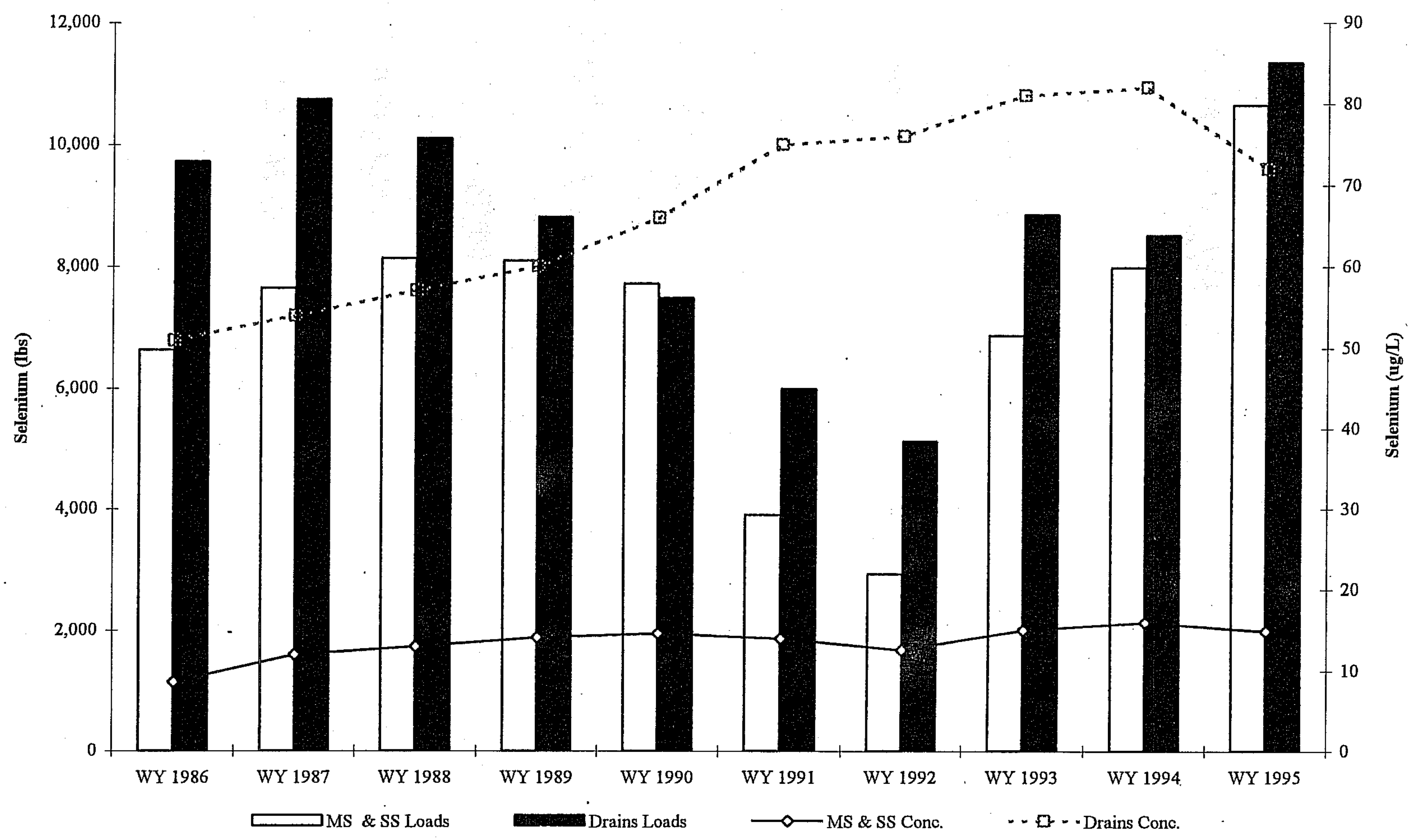


Figure-6
Annual Selenium Loads and Concentrations for the Drains and Sloughs: WYs 86-95



Increases of 25%, 23%, and 23% over WY 94 were noted in the combined selenium, boron, and salt loads from Mud Slough (north) and Salt Slough for WY 95 (Table 6 and Figures 4-6). A statistical analysis was not conducted to determine if these differences are significant.

Figure 7 depicts the combined WY 95 monthly selenium loads for Mud Slough (north) and Salt Slough. Of interest are the peak loads from February through April, which correspond to pre-planting irrigations, precipitation and wetland discharges. There was a second peak loading period during July and August of WY 95 that corresponds to the peak agricultural irrigation season. The selenium load levels observed in WY 95 are higher than the levels observed prior to the 1988 Basin Plan amendment. The selenium loads generated between February and April account for about 30% of the total selenium load (10,694 lbs) during WY 95.

Figures 8-11 show a comparison of monthly mean boron and selenium concentrations in the two sloughs from WYs 93 to 95. This time period was selected to note trends in concentration distributions over the past three consecutive years which were subject to varying availability of water. The concentrations of selenium, boron, and salts were compared to the water quality objectives which were part of the 1988 Basin Plan (CRWQCB, 1988) amendment and became effective in October 1993. The applicable water quality objectives are detailed in Table 7.

Monthly mean selenium concentrations in Salt Slough during WY 95 were virtually the same as those found in WY 93, with the largest peak occurring during February in both WYs. The monthly mean selenium water quality objective of 10 μg/L was exceeded in Salt Slough in all months except October, during WY 95 (Figure 9). The objective exceedance is attributable to subsurface drainage discharges which were diverted to this slough in WY 95.

In addition, the maximum selenium objective (26 μg/L) was exceeded five times during WY 95. The highest selenium concentration recorded in the slough during WY 95 was 38 μg/L (Appendix C).

The selenium mean monthly WQO was not exceeded in Mud Slough (north) during WY 95. The highest concentration of selenium recorded in Mud Slough (north) was 17 μg/L which is below the 26 μg/L selenium maximum WQO.

During October of each year, the annual flooding of Grassland area wild life refuges and duck clubs takes place. The mean monthly selenium water quality objective for waterfowl habitat supply (2 μg/L) was met during October for all water bodies and for the San Luis Spillway Ditch year-round (Appendix B). The objective was, however, exceeded several times in the CCID Main Canal, with a maximum value of 3.8 μg/L. It is not known if the water supplies in the CCID Main Canal were used for wetland irrigation during periods in which the objective was exceeded. Water in the CCID Main Canal, where it is measured at Russell Avenue, originates at the Delta-Mendota Canal. Selenium concentrations in the Delta-Mendota Canal have been known to exceed the waterfowl habitat supply objective (2 μg/L) (Chilcott et al., 1995).

Figure-7
Monthly Selenium Total Loads Discharged from Grasslands Watershed (Mud and Salt Slough Combined): WY 95

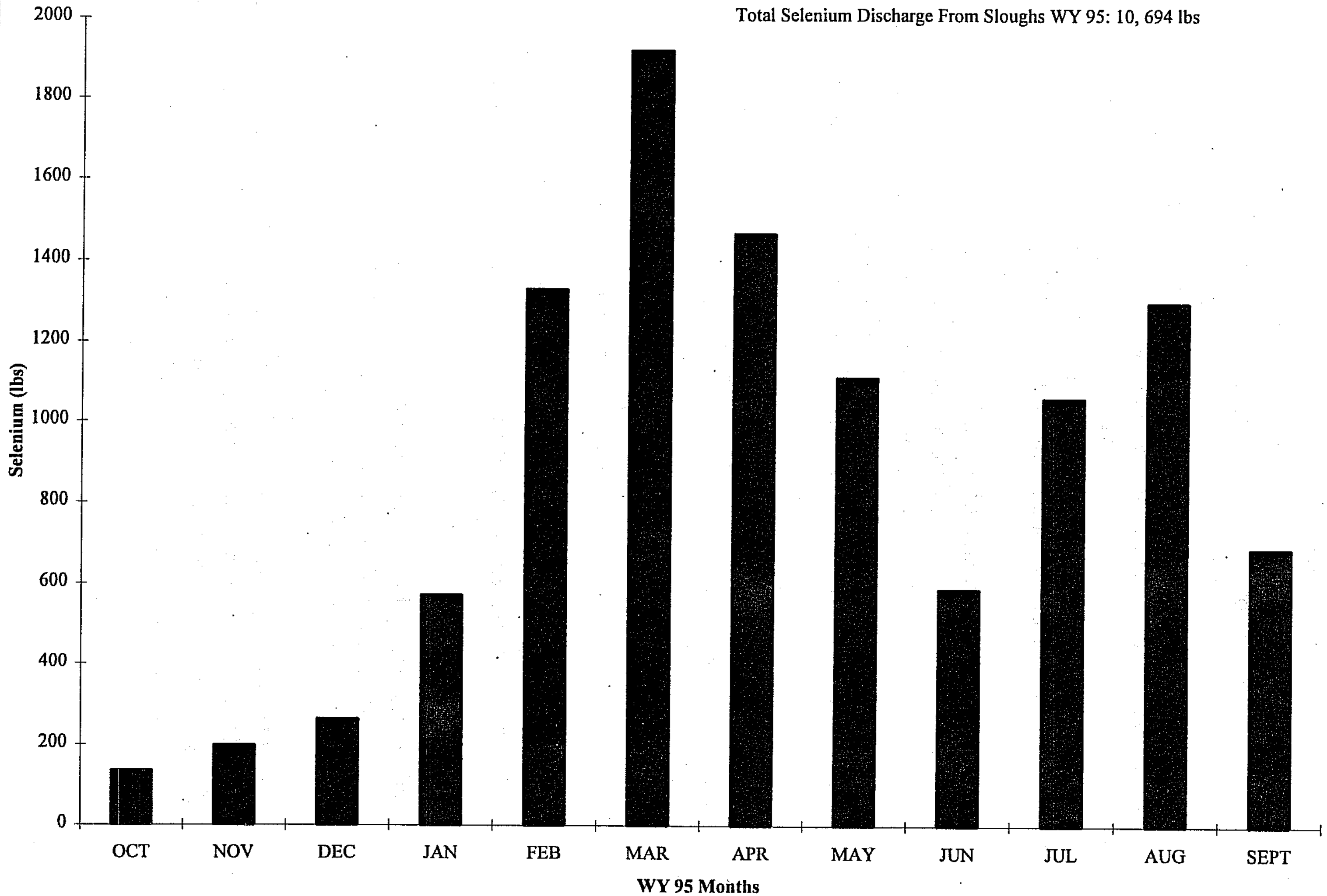


Figure-8
Monthly Mean Selenium Concentrations in Mud Slough (north) at the San Luis Drain: WYs 93-95

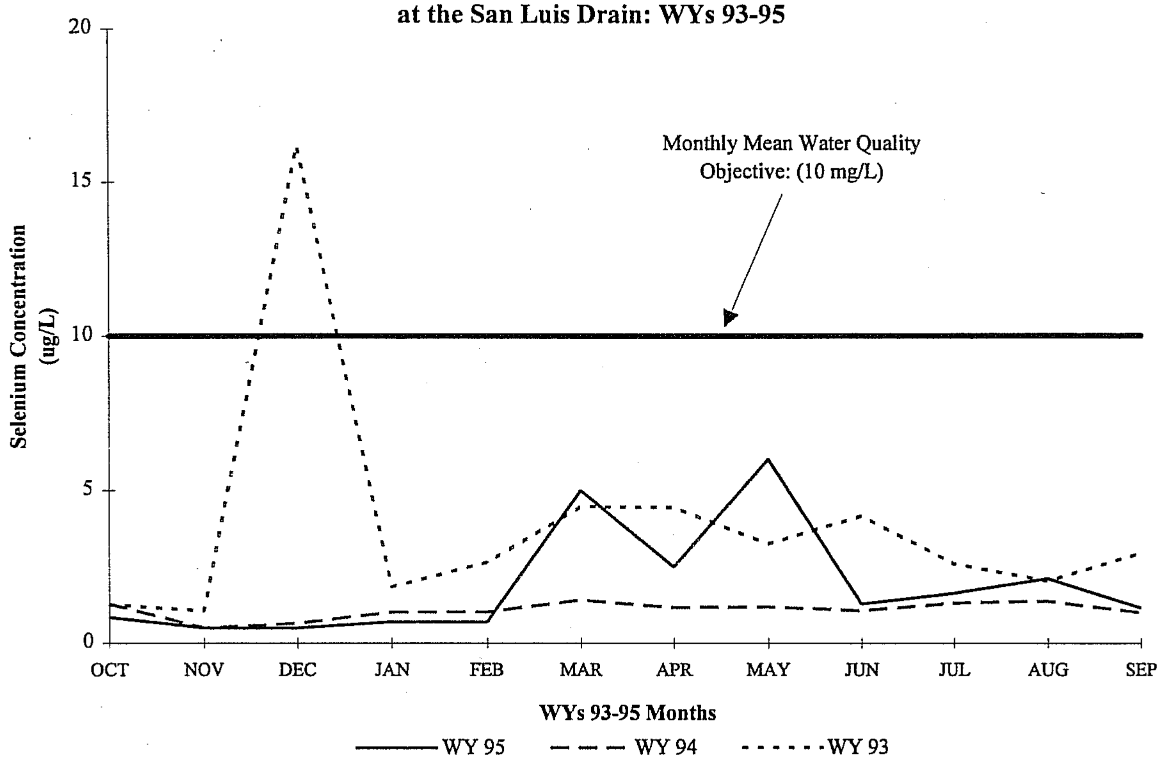


Figure-9
Monthly Mean Selenium Concentrations in Salt Slough at Lander Avenue: WYs 93-95

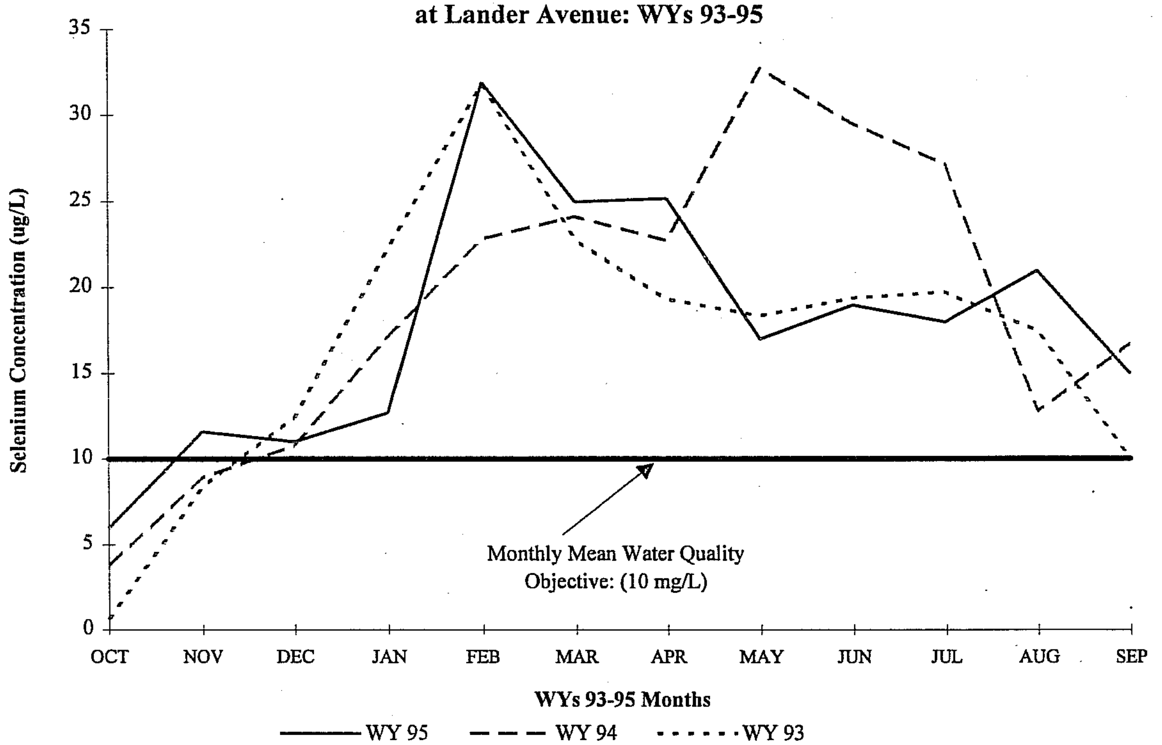


Figure-10
Monthly Mean Boron Concentrations in Mud Slough (north) at the San Luis Drain: WYs 93-95

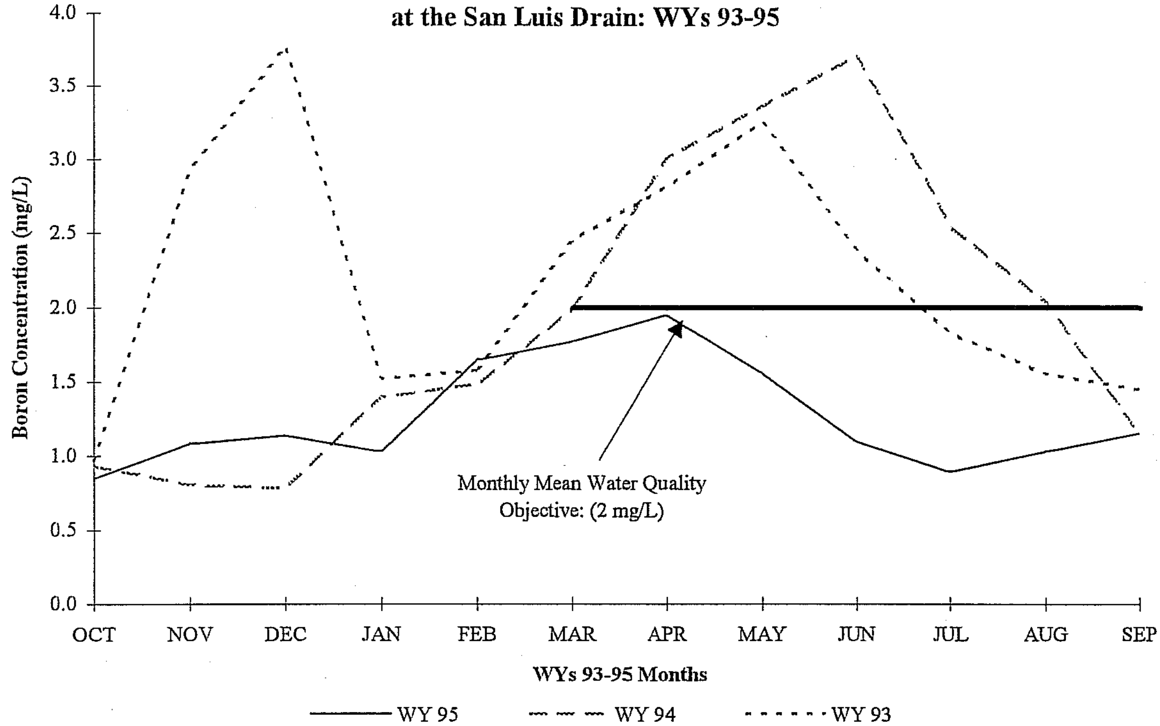


Figure-11
Monthly Mean Boron Concentrations in Salt Slough at Lander Avenue: WYs 93-95

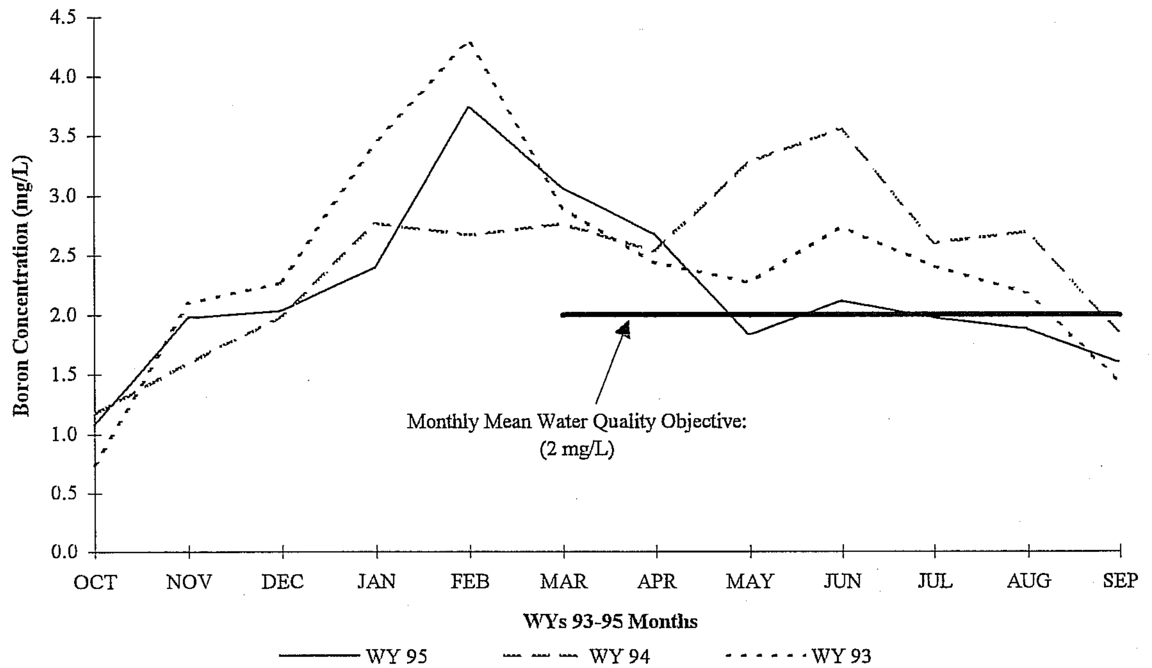


TABLE 7

Water Quality Objectives for Mud Slough (north) and Salt Slough (as adopted into the 1988 Basin Plan)

Constituent	Maximum Concentration
Selenium (μg/L)	26 10 (monthly mean)
Boron (mg/L) (March 15-Sept 15)	5.8 2.0 (monthly mean)
Molybdenum (μg/L)	58 19 (monthly mean)

The 1988 adopted boron water quality objective apply on a seasonal basis. The seasonal (March 15 to September 15) monthly mean boron objective of 2 mg/L was not exceeded in Mud Slough (north) during WY 95 (Figure 10). The maximum objective for boron (5.8 mg/L) was not exceeded during WY 95. Maximum concentrations remained below 4.0 mg/L (Appendix C).

The seasonal monthly mean boron objective in Salt Slough was exceeded during March (3.1 mg/L), April (2.7 mg/L) and June (2.1 mg/L) of WY 95 (Figure 11). The monthly concentration distribution of boron followed the same pattern as selenium and was typical of previous years. All boron measurements in Salt Slough were below the maximum objective of 5.8 mg/L.

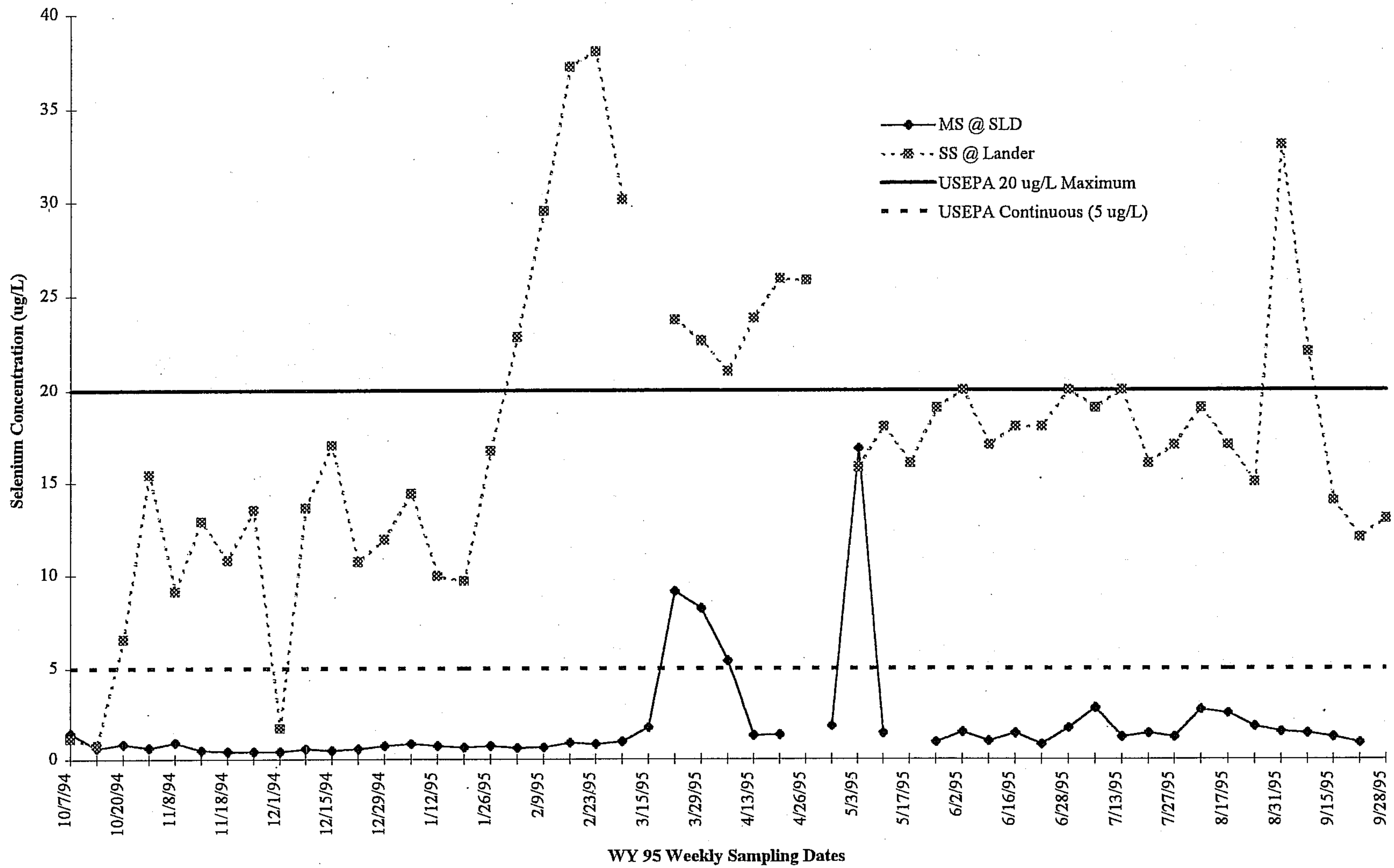
The water quality objective for molybdenum (19μg/L monthly mean) was not exceeded in Mud Slough (north) during WY 95. In Salt Slough, the molybdenum objective was met throughout the period sampled. Molybdenum analysis, however, were only conducted quarterly. A concentration distribution pattern for molybdenum as a function of time can not be established with the limited data set. The maximum molybdenum objective of 50 μg/L was met during all sampling events in both sloughs, with maximum measured concentrations reported below 14 μg/L.

On 22 December 1992, the US Environmental Protection Agency (USEPA) promulgated the National Toxics Rule according to §303(c)(2)(B), of the Federal Clean Water Act. This promulgation included a more stringent selenium water quality criteria of 5 μg/L as a four-day average and a maximum criteria of 20 μg/L for Mud Slough (north) and Salt Slough. Frequency of data collection in this monitoring program does not allow for the calculation of a four-day average concentration. Selenium concentration data from the Regional Boards weekly grab sampling program for Mud Slough (north) and Salt Slough are compared to the USEPA criteria in Figure 12. Although not directly comparible, the weekly grab samples indicate that the USEPA continuous criteria (5 μg/L 4-day average) would have been exceeded almost continuously in Salt Slough and rarely in Mud Slough (north). The USEPA maximum selenium criteria (20 μg/L) was exceeded on 13 separate occassions in Salt Slough with the majority of high concentrations occurring during the flood season between January and April. Use of the USEPA promulgated criteria is unclear since they are in conflict with those specifically adopted for agricultural discharges in the 1988 Basin Plan amendment (Resolution No. 88-195). They have been discussed here for comparison purposes.

In summary, selenium, boron, and salt loads remained elevated in WY 95, reversing the trend of lower loads realized during the extended drought of the late 1980s and early 1990s. The increased loads in WY 95 may be attributable to greater water use. The increased loads coupled with more efficient water distribution and irrigation management has resulted in less available dilution flows and the subsequent increased concentrations of the constituents of most concern.

In addition, although both Mud Slough (north) and Salt Slough are effluent dominated, elevated boron concentrations are present in Mud Slough (north) whether subsurface drainage water is being discharged to the slough or not. However, Salt Slough requires the introduction of subsurface drainage water for boron to be present at elevated levels. Selenium is not present at elevated levels in either slough without the influence of subsurface drainage, while molybdenum is present in Mud Slough (north) and Salt Slough regardless of whether subsurface drainage water is present or not.

Figure-12
Weekly Selenium Concentrations for Mud Slough (north) at the San Luis Drain and Salt Slough at Lander Avenue: WY 95



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APPENDIX A

Mineral and Trace Element Water Quality Data for Inflow Monitoring Stations Listed in Order by Map Index Number

Legend of Abbreviations

Abbreviation	Abbreviation Explanation
EC	Electric Conductivity
Se	Selenium
Mo	Molybdenum
Cr	Chromium
Cu	Copper
Ni	Nickel
Pb	Lead
Zn	Zinc
B	Boron
Cl	Chlorine
$S0_4$	Sulfate
HDNS	Hardness

Main (Firebaugh) Drain at Russel Avenue (MER556)

Location: Latitude: 36°55'27", Longitude 120°39'11". In SW 1/4, SW 1/4, SW 1/4, Sec. 34, T.11S.,R.12E. East side of Russel Avenue, 2.7 miles south of Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/7/94	915	64	8.1	2630	30							2.8			
10/12/94	740	57	7.9	4260	60							6.1			
10/20/94	920	60	8.0	3220	29							4.1			
10/27/94	852	60	8.0	4370	59	48	15	7	17	<5	24	5.7	440	1600	820
11/8/94	850	48	8.0	2040	28							1.7			
11/10/94	1225	54	8.2	3260	33							3.0			
11/18/94	920	49	8.0	4670	91							6.0			
11/22/94				3940	66	36						4.5	390	1400	860
12/1/94	1434	46		4140	65							4.8			
12/9/94	931	40		6700	124							7.4			
12/15/94	950	46		4630	79							5.9			
12/21/94	1036	48		5540	108							6.9			
12/29/94	915	49	8.5	6270	138	78						9.7	730	2800	1700
1/12/95	930	54	7.9	5230	126							6.9			
1/19/95	930	47	8.0	6247	142							9.9			
1/26/95	1120	53	7.9	2430	46	12						2.5	240	730	520
2/3/95	1040	56	8.1	5820	132							6.9			
2/9/95	1700	58	8.3	4410	92							5.0			
2/17/95	930	51	7.8	3710	67							3.9			
2/23/95	850	57	7.6	4310	92	23						4.7	450	1400	1100
3/3/95	1025	60	8.0	4460	91							6.1			
3/9/95	915	56	8.1	5230	117							7.5			
3/23/95	1130	54	7.3	4790	99							5.7			
3/29/95	805	64	7.4	6200	142							7.7	650	2400	1800
4/6/95	725	66	8.0	6070	150							7.6			
4/13/95	1230	62	8.0	5670	135							6.5			
4/21/95	910	56	8.4	6200	156							7.3			
4/28/95	955	66	8.1	5260	126	22						6.7	600	2000	130
5/3/95	915	65	8.1	5460	144							7.6			
5/12/95	910	60	8.3	2840	62							3.0			
5/17/95	1200	68	7.9	2920	67							3.6			
5/26/95	930	64	7.7	3960	94							4.8	380	1200	900
6/2/95	910	68	7.4	3230	65							3.7			
6/9/95	900	67	8.0	3570	70							4.1			
6/23/95	900	74	8.0	2730	49							3.0			
6/28/95	1015	76	7.7	2190	33							2.7	160	660	560
7/6/95	915	76	8.1	3310	44							3.5			
7/13/95	900	71	7.5	3460	63							4.2			
7/20/95	910	77	8.1	2560	41							3.1			
7/27/95	1235	85	7.6	2150	37	8						2.8	180	760	540
8/3/95	1030	80	7.7	2460	41							3.0			
8/10/95	910	79	8.1	1910	26							2.3			
8/17/95	905	69	7.9	2140	29							2.6			
8/24/95	935	78	7.0	255	1.0							0.1			
8/31/95	1015	74	8.0	2540	37							3.0	200	810	570
9/7/95	900	74	8.1	2960	50							3.7			
9/15/95	911	72	8.0	3060	64							3.8			
9/22/95	935	72	7.6	2540	39							3.4			
9/28/95	1030	68	7.6	2640	42							3.3	230	840	530
Count		48	44	49	49	7	1	1	1	1	1	49	12	12	12
Min		40	7.0	255	1	8	15	7	17	<5	24	0.1	160	660	130
Max		85	8.5	6700	156	78	15	7	17	<5	24	9.9	730	2800	1800
Mean		62	7.9	3890	76	32	15	7	17	<5	24	4.8	388	1383	836
Geo Mean		62	7.9	3528	62	25	15	7	17	<5	24	4.2	343	1235	697
Median		63	8.0	3710	65	23	15	7	17	<5	24	4.2	385	1300	695

Panoche Drain at O'Banion Gauge Station (MER501)

Location: Latitude 36°55'14", Longitude 120°41'43". In SW 1/4, SW 1/4, SW 1/4, Sec. 32, T.11S., R.12E. Located 0.5 miles south of CCID Main Canal, 1.9 miles west of Russel Road. 5.5 miles SW of Dos Palos. 3.4 miles SW of South Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se	Mo	Cr	Cu	Ni	Pb	Zn	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
					µg/L										
10/7/94	920	62	7.6	4860	23							7.9			
10/12/94	800	55	7.9	5130	24							8.3			
10/20/94	930	60	8.0	5530	144							8.5			
10/27/94	927	59	8.0	5130	117	12	19	1	8	<5	13	7.8	710	1600	1100
11/8/94	905	48	7.8	5060	98							7.8			
11/10/94	1250	57	8.3	4990	129							8.0			
11/18/94	930	48	8.0	4690	85							7.7			
11/22/94	1000			4460	72	11						7.0	580	1200	1100
12/1/94	1449	52		4500	83							7.6			
12/9/94	943	42		4400	60							7.5			
12/15/94	1013	47		4310	71							6.3			
12/21/94	1051	50		4440	84							7.8			
12/29/94	935	50	8.2	4380	97	9						6.9	630	1400	1200
1/30/95					75	5						5.8			
2/3/95	1335	65	8.1	3750	71							5.3			
2/17/95	955	55	7.8	4920	92							8.1			
3/3/95	1135	62	7.7	5220	100							8.1			
3/15/95	1315				53							4.5			
3/23/95	1145	54	7.4	4580	120							7.7			
3/29/95	825	65	7.6	4460	89							7.5	550	1400	1200
4/6/95	740	61	8.2	4560	94							7.0			
4/13/95	1102	60	7.8	5320	105							8.3			
4/21/95	1125	55	8.1	4810	106							7.6			
4/28/95	1040	66	7.9	5160	95							8.9	710	1600	130
5/3/95	930	61	7.9	4430	100							7.9			
5/12/95	1025	58	8.1	4750	82							7.7			
5/26/95	1045	64	7.9	4900	94							7.7	620	1400	1300
6/2/95	930	66	6.9	4920	104							7.2			
6/9/95	950	64	7.8	4590	79							7.1			
6/23/95	920	70	7.8	4420	73							7.3			
6/28/95	1035	72	7.7	4840	82							7.7	580	1300	1200
7/6/95	935	70	7.8	5680	89							8.0			
7/13/95	730	68	7.7	4780	76							8.0			
7/20/95	955	75	7.9	4890	90							8.2			
7/27/95	900	72	8.0	4830	80	12						7.1	560	1400	1000
8/3/95	1110	78	7.8	4300	67							6.7			
8/10/95	920	72	7.7	3880	74							5.6			
8/17/95	945	68	7.8	4340	74							6.8			
8/24/95	1045	77	6.7	4110	70							5.9			
8/31/95	1030	72	7.8	4110	67							5.8	460	1200	1000
9/7/95	932	72	8.0	4420	85							6.8			
9/15/95	931	70	7.8	4150	79							6.5			
9/22/95	851	67	7.0	5310	124							8.1			
9/28/95	1245	73	8.0	4550	106							7.3	580	1400	1100
Count		41	37	42	44	5	1	1	1	1	1	44	10	10	10
Min		42	6.7	3750	23	5	19	1	8	<5	13	4.5	460	1200	130
Max		78	8.3	5680	144	12	19	1	8	<5	13	8.9	710	1600	1300
Mean		62	7.8	4687	86	10	19	1	8	<5	13	7.3	598	1390	1033
Geo Mean		62	7.8	4668	82	9	19	1	8	<5	13	7.2	594	1384	910
Median		64	7.8	4640	84	11	19	1	8	<5	13	7.6	580	1400	1100

Agatha Canal at Mallard Road (MER506)

Location: Latitude: 36°56'12", Longitude 120°42'07". In NE 1/4, NW 1/4, SW 1/4, Sec. 7, T.11S., R.11E. South of Santa Fe Grade at Brito, west of Mallard Road. 4.5 miles west of Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/7/94	935	64	8.8	841	2.2							0.47			
10/12/94	825	61	8.2	957	2.2							0.64			
10/20/94	945	64	8.1	623	2.0							0.28			
10/27/94	948	62	8.4	899	4.4	2						0.54	130	120	180
11/22/94	1020			738	1.5	3						0.36	110	91	140
12/29/94	1005	49	8.6	928	2.1	3						0.63	140	130	180
1/26/95	1041	54	7.8	2080	23	3						3.1	250	540	470
2/23/95	830	58	7.7	4810	95							6.8	550	1400	1300
3/29/95	1145	69	8.0	4500	86							7.5	560	1400	1200
4/13/95	1250	62	8.0	5370											
4/28/95	1240	67	8.3	340	1.8							0.47	28	72	81
5/26/95	1050	67	8.0	4110	76							6.2	470	1300	1100
6/28/95	845	62	6.9	3160	41							4.6	330	880	720
7/27/95	1055	76	8.4	162	1.1							0.12	9	20	35
8/31/95	1115	75	7.9	3420	49							4.7	360	1000	870
9/28/95	1045	69	7.7	4170	92							6.0	500	1300	900
Count		15	15	16	15	4						15	12	12	12
Min		49	6.9	162	1.1	2						0.1	9	20	35
Max		76	8.8	5370	95	3						7.5	560	1400	1300
Mean		64	8.0	2319	32	3						2.8	286	688	598
Geo Mean		64	8.0	1514	9.7	3						1.3	179	349	366
Median		64	8.0	1520	4.4	3						0.6	290	710	600

Hamburg Drain near Camp 13 Slough (MER504)

Location: Latitude: 36°56'20", Longitude 120°45'26". In SE 1/4, SE 1/4, SW 1/4, Sec. 27, T.11S., R.11E. 50 feet south of CCID main canal. 9.2 miles S-SE of Los Banos. 6.7 miles W-SW of South Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/7/94	850	59	8.1	4020	34							5.1			
10/12/94	715	55	7.8	4110	41							5.6			
10/20/94	855	59	6.7	4850	68							5.3			
10/27/94	820	58	7.9	4990	72	6	14	<1	5	<5	9	5.4	760	1600	1800
11/8/94	840	48	7.5	4220	48							4.6			
11/10/94	1150	57	8.0	4830	70							5.3			
11/18/94	905	46	7.8	4990	75							4.3			
11/22/94	853	42		4920	70	8						5.3	730	1500	510
12/1/94	1410	56		4360	50							5.0			
12/9/94	908	41		4790	60							5.4			
12/15/94	922	48		4740	61							5.3			
12/21/94	1009	47		5000	86							4.8			
1/26/95	830	51	8.6	1230	5.2	2						3.4	180	240	100
2/3/95	915	56	8.3	5370	31							9.4			
2/9/95	1450	68	8.2	6190	104							7.4			
2/17/95	955	54	6.7	5730	77							8.0			
2/23/95	915	58	7.5	5000	72							5.3	680	1600	1800
3/3/95	945	59	7.7	4210	71							3.9			
3/16/95	730	58			95							5.0			
3/23/95	1150	67	7.3	3730	92							4.0			
3/29/95	715	57	7.1	5550	92							6.6	810	1900	2000
4/6/95	930	66	8.4	5680	105							6.0			
4/13/95	930	60	7.8	5570	93							6.5			
4/21/95	845	54	8.3	5570	92							6.6			
4/28/95	905	62	7.9	4920	76	4						5.9	690	1600	1600
5/3/95	845	62	7.8	4530	64							6.5			
5/12/95	845	57	8.1	5450	96							6.0			
5/17/95	1039	78	8.6	5120	71							7.1			
5/26/95	850	57	8.4	4360	38							5.4	520	1400	1800
6/2/95	850	63	7.4	4150	71							6.1			
6/9/95	840	62	7.7	5150	74							5.6			
6/23/95	845	68	7.8	5160	70							6.7			
6/28/95	925	68	7.5	4670	64							5.4	560	1300	1500
7/6/95	845	68	8.0	5440	70							5.3			
7/13/95	1335	72	7.9	4620	71							5.2			
7/20/95	845	68	7.9	4210	61							4.8			
7/27/95	1250	80	7.6	4210	65							5.2	580	1400	1400
8/3/95	940	75	7.8	3290	50							3.2			
8/10/95	825	68	7.6	5200	83							5.3			
8/17/95	850	65	7.5	4160	55							4.8			
8/24/95	915	70	6.5	2890	37							2.6			
8/31/95	945	76	7.7	6090	124							5.9	820	1900	1700
9/7/95	844	70	7.9	5180	60							6.7			
9/15/95	837	67	7.4	5800	67							8.3			
9/22/95	823	72	6.7	744	3.8							0.8			
9/28/95	955	67	8.1	752	3.9							0.6	69	180	210
Count		46	40	45	46	4	1	1	1	1	1	46	11	11	11
Min		41	6.5	744	4	2	14	<1	5	<5	9	0.6	69	180	100
Max		80	8.6	6190	124	8	14	<1	5	<5	9	9.4	820	1900	2000
Mean		61	7.7	4572	66	5	14	<1	5	<5	9	5.4	582	1329	1311
eo Mean		61	7.7	4270	56	4	14	<1	5	<5	9	5.0	487	1085	970
Median		61	7.8	4850	70	5	14	<1	5	<5	9	5.3	680	1500	1600

Camp 13 Slough at Gauge Station (MER505)

Location: Latitude 36°56'21", Longitude 120°45'22". In SE 1/4, SE 1/4, SW 1/4, Sec. 27, T.11S., R.11E. 150 feet north of CCID Main Canal, 6.4 miles west of Russel Avenue. 9.2 miles SE of Los Banos. 6.7 miles SW of South Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/7/94	855	68	8.7	667	0.9							0.20			
10/12/94	725	61	8.1	691	1.5							0.24			
10/20/94	900	60	7.3	4490	94							6.9			
10/27/94	829	59	7.9	4090	71	8						6.2	540	1300	930
11/22/94	902	43		4120	65	18						5.8	490	1300	370
12/29/94	840	49	8.2	4620	96	14						7.8	640	1500	1300
1/26/95	840	52	8.1	2190	32	7						2.6	240	620	470
2/23/95	800	58	8.0	630	3.3							0.49	69.0	110	150
3/29/95	720	57	7.2	6110	118							8.0	720	2200	1800
4/13/95	915	61	7.9	5510											
4/28/95	925	64	8.0	5200	105							6.7	660	1900	110
5/26/95	900	64	8.9	266	2.1							0.27	22	49	73
6/28/95	940	74	8.1	1900	20							2.3	200	470	500
7/27/95	1300	82	7.9	3370	56							5.7	410	1100	870
8/31/95	952	77	8.3	680	4.8							0.41	83	110	150
9/28/95	1005	69	8.3	311	1.9							0.18	30	44	80
Count		16	15	16	15	4						15	12	12	12
Min		43	7.2	266	0.9	7						0.2	22	44	73
Max		82	8.9	6110	118	18						8.0	720	2200	1800
Mean		62	8.1	2802	45	12						3.6	342	892	567
Geo Mean		62	8.0	1816	16	11						1.6	206	460	340
Median		61	8.1	2780	32	11						2.6	325	860	420

Charleston Drain at CCID Main Canal (MER502)

Location: Latitude 36°56'59" Longitude 121°46'48". In NE 1/4, SE 1/4, NE 1/4, Sec. 29, T.11S., R.11E. North side of CCID Main Canal, 8.7 miles S-SE of Los Banos. 7.9 miles W-SW of South Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se	Mo	Cr	Cu	Ni	Pb	Zn	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
					µg/L										
10/27/94	809	59	8.0	2540	24	3	16	6	15	<5	22	1.9	290	800	690
11/8/94	830	49	6.9	3450	37							2.9			
11/10/94	1205	56	7.9	4690	66							5.3			
11/18/94	855	47	7.6	4190	49							3.8			
11/22/94	842	43		4520	58	11						3.9	500	1600	430
12/1/94	1357	48	7.6	4830	63							4.5			
12/9/94	848	38	8.7	2990	34							2.5			
12/15/94	903	44		4760	56							4.6			
12/21/94	949	46	8.5	2350	25							1.9			
12/29/94	820	41	7.8	2780	25	9						2.3	300	950	890
1/26/95	925	53	8.0	3070	49	4						2.6	380	960	980
2/3/95	945	58	7.9	5140	89							4.7			
2/9/95	1530	64	8.3	5910	105							5.2			
2/17/95	850	54	5.6	6010	96							5.3			
2/23/95	745	56	7.3	5750	92	10						5.1	830	1800	2200
3/3/95	900	59	7.4	4980	88							4.0			
3/29/95	700	57	7.1	5740	110							4.9	760	2000	2000
4/6/95	705	65	8.5	5820	117							5.0			
4/13/95	900	60	7.6	5650	104							5.1			
4/21/95	830	54	7.1	4660	76							4.5			
4/28/95	855	62	7.5	3100	54	3						2.6	390	1000	840
5/3/95	820	60	7.9	2930	52							2.8			
5/12/95	830	58	8.0	5310	96							4.8			
5/17/95	1025	66	7.6	4880	79							4.9			
5/26/95	840	60	7.3	5070	99							5.4	710	1500	1800
6/2/95	840	62	7.5	4150	65							4.0			
6/9/95	830	62	7.0	4250	61							4.3			
6/23/95	830	70	8.0	4770	104							5.0			
6/28/95	900	70	7.2	4680	87							4.8	730	1100	1400
7/6/95	820	74	8.1	4500	74							3.3			
7/13/95	1345	78	7.4	3260	45							3.0			
7/20/95	830	70	8.2	4500	2.0							0.2			
7/27/95	1235	80	7.3	3120	56	4						2.8	430	1000	950
8/3/95	920	75	7.7	2600	34							2.2			
8/10/95	815	71	7.2	4180	71							3.4			
8/17/95	840	68	6.9	3890	67							3.5			
8/24/95	850	73	6.9	3270	50							2.7			
8/31/95	930	70	7.7	4960	89							4.3	600	1600	1600
9/7/95	836	70	8.3	4110	59							3.9			
9/15/95	823	67	6.6	4560	64							4.3			
9/22/95	759	65	6.6	4080	47							5.1			
9/28/95	940	69	8.2	304	1.3							0.2	27	40	77
Count		42	40	42	42	7	1	1	1	1	1	42	12	12	12
Min		38	5.6	304	1.3	3	16	6	15	<5	22	0.2	27	40	77
Max		80	8.7	6010	117	11	16	6	15	<5	22	5.4	830	2000	2200
Mean		61	7.6	4198	65	6	16	6	15	<5	22	3.7	496	1196	1155
Geo Mean		60	7.5	3912	53	5	16	6	15	<5	22	3.2	396	935	900
Median		61	7.6	4500	63	4	16	6	15	<5	22	4.0	470	1050	970

Almond Drive Drain (MER555)

Location: Latitude 36°59'55", Longitude 120°49'00". In SW 1/4, SW 1/4, SW 1/4, Sec. 6, T.11S., R.11E. North side of Almond Drive, 1.1 miles east of Mercy Springs Drain, 100 feet east of CCID Main Canal. 4.7 miles south of Los Banos

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/27/94	748	60	7.9	731	1.1							0.27	120	75	140
11/22/94	818	47		694	1.8							0.29	110	82	140
12/29/94	755	48	8.4	808	3.7							0.35	120	110	180
1/26/95	730	50	8.0	2370	4.8							3.0	270	560	510
2/23/95	730	56	7.9	880											
3/29/95	650	59	7.3	2880											
4/28/95	835	63	7.3	91	0.6							0.04	3	10	28
5/26/95	820	62	6.9	70											
6/28/95	830	78	7.8	284											
7/27/95	1215	82	8.0	526	1.7							0.49	49	110	120
8/31/95	910	76	7.9	466											
9/28/95	925	69	8.3	311											
Count		12	11	12	6							6	6	6	6
Min		47	6.9	70	0.6							0.04	3.2	10	28
Max		82	8.4	2880	4.8							3.0	270	560	510
Mean		62	7.8	843	2.3							0.74	112	158	186
Geo Mean		61	7.8	514	1.8							0.34	64	86	135
Median		61	7.9	610	1.7							0.32	115	96	140

Rice Drain at Mallard Road (MER509)

Location: Latitude 36°59'22" Longitude 120°14'42". In NE 1/4, NW 1/4, SW 1/4, Sec. 7, T.11S., R.11E. South of Santa Fe Grade at Brito, 50 feet west of Mallard Road. 4.5 miles west of Dos Palos.

		Temp		EC	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO_4	HDNS
Date	Time	°F	pH	µmhos/cm	µg/L							mg/L	mg/L	mg/L	mg/L
10/27/94	955	60	8.2	1500	2.2	5						1.8	180	310	350
11/22/94	1012			2500	1.5	14						4.0	320	610	580
12/29/94	1015	49	7.9	2250	1.0	10						3.4	250	550	580
1/26/95	1050	53	7.7	2640	4.2	12						3.7	300	810	630
2/23/95	840	58	7.8	3740											
3/29/95	1140	68	7.9	5840											
4/13/95	1255	62	8.2	5200											
4/28/95	1230	67	8.0	4620	2.6							12	600	1500	97
5/26/95	1145	68	7.9	3990											
6/28/95	850	70	7.7	3370											
7/27/95	1100	78	8.0	2420	5.0							5.6	290	720	410
8/31/95	1122	74	8.0	2310											
9/28/95	1040	67	7.7	2640											
Count		12	12	13	6	4						6	6	6	6
Min		49	7.7	1500	1.0	5						1.8	180	310	97
Max		78	8.2	5840	5.0	14						12	600	1500	630
Mean		65	7.9	3309	2.8	10						5.1	323	750	441
Geo Mean		64	7.9	3088	2.4	10						4.3	302	671	379
Median		67	7.9	2640	2.4	11						3.9	295	670	500

Boundary Drain at Department of Fish and Game Pump (MER521)

Location: Latitude 37°06'32", Longitude 120°46'44". In NE 1/4, SE 1/4, NE 1/4, Sec. 32, T.9S., R.11E. North of Henry Miller Road. 4.6 miles NE of Los Banos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/27/94	1117	63	7.6	1280	1.0							0.48	220	150	250
11/22/94	1005	47		1313	0.7							1.00	600	480	570
12/29/94	1155	52	7.8	1900	0.4							0.61	340	210	340
1/26/95	1300	55	7.4	2230	0.6							0.64	420	310	460
2/23/95	1040	59	7.9	1500											
Count		5	4	5	4							4	4	4	4
Min		47	7.4	1280	0.4							0.48	220	150	250
Max		63	7.9	2230	1.0							1.00	600	480	570
Mean		55	7.7	1645	0.7							0.68	395	288	405
Geo Mean		55	7.7	1606	0.6							0.66	371	262	386
Median		55	7.7	1500	0.6							0.63	380	260	400

Salt Slough Ditch at Hereford Road (MER528)

Location: Latitude 37°08'30" Longitude 120°45'17". In NW 1/4, NE 1/4, NW 1/4, Sec. 22, T.9S., R.11E. 3.0 miles north on Hereford Road from Henry Miller Road.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/27/94	1133	62	7.6	953	0.5	6						0.24	150	94	220
11/22/94	740	45		1130	<.4							0.24	170	120	250
12/29/94	1215	50	8.3	1010	3.0							0.44	150	140	230
1/26/95	1320	55	7.7	613	0.6							0.16	82	61	210
2/23/95	1030	59	8.0	1070											
3/29/95	1235	65	8.3	1140											
4/13/95	1405	65	7.5	782											
4/28/95	1400	65	7.9	595	0.8							0.15	68	66	59
5/25/95	1120	71	8.0	477											
6/28/95	1020	78	8.1	697											
7/27/95	1140	82	8.4	476	0.9							0.14	54	50	120
8/31/95	1240	78	8.1	740											
9/28/95	850	69	7.7	655											
Count		13	12	13	6	1						6	6	6	6
Min		45	7.5	476	<.4	6						0.14	54	50	59
Max		82	8.4	1140	3.0	6						0.44	170	140	250
Mean		65	8.0	795	1.0	6						0.23	112	89	182
Geo Mean		64	8.0	762	0.8	6						0.21	102	83	163
Median		65	8.0	740	0.7	6						0.20	116	80	220

APPENDIX B

Mineral and Trace Element Water Quality Data for Internal Flow Monitoring Stations
Listed in Order by Map Index Number

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CCID Main at Russel Avenue (MER510)

Location: Latitude 36°55'28", Longitude 120°39'11". In SE 1/4, SE 1/4, SE 1/4, Sec. 33, T.11S., R.12E. 2.7 miles south of Dos Palos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/27/94	848	61	8.5	624	1.3							0.23	95.0	61.0	120
11/22/94	922	47		675	1.3							0.27	100	73.0	130
12/29/94	910	49	8.5	1610	2.2							1.40	180	480	470
1/26/95	1115	53	8.6	810	3.8							0.46	100	140	180
2/23/95	845	58	8.5	301											
3/29/95	800	65	8.3	161											
4/13/95	1223	61	8.4	975											
4/28/95	1005	63	8.5	82	0.6							0.03	2	6	26
5/26/95	925	62	8.0	69											
6/28/95	1005	76	8.5	227											
7/27/95	1330	87	8.3	173	1.5							0.12	14	30	44
8/31/95	1010	76	8.3	520											
9/28/95	1020	69	8.3	288											
Count		13	12	13	6							6	6	6	6
Min		47	8.0	69	0.6							0.03	2.4	5.8	26
Max		87	8.6	1610	3.8							1.4	180	480	470
Mean		64	8.4	501	1.8							0.42	82	132	162
Geo Mean		63	8.4	342	1.5							0.22	42	61	107
Median		62	8.4	301	1.4							0.25	98	67	130

Santa Fe Canal at Henry Miller Road (MER519)

Location: Latitude 37°05'59", Longitude 120°49'44". In NE 1/4, NE 1/4, Sec. 1, T.10S., R.10E. 0.3 miles east of Lander Avenue. 3.0 miles north of Gustine.

Date	Time	Temp °F	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/7/94	1015	68	8.3	746	1.3							0.31			
10/12/94	930	61	8.4	792	1.3							0.33			
10/20/94	1015	64	8.1	571	0.8							0.21			
10/27/94	1043	62	7.2	677	0.8							0.23	110	55	130
11/22/94	1030	49		798	1.7							0.35	110	96	160
12/29/94	1115	50	8.3	2190	4.7							2.20	280	470	670
3/29/95	1250	71	8.0	3880								5.40	470	1200	990
4/13/95	1340	66	8.5	2300	0.8							0.19			
4/28/95	1320	68	9.3	557	2.9							0.69	52	100	71
5/25/95	1043	70	7.4	318	0.8							0.25	24	48	88
6/28/95	940	72	8.1	747	2.9							0.66	71	130	170
7/27/95	1225	88	8.3	590	1.8							0.49	60	100	130
8/31/95	1150	78	8.4	637	2.0							0.44	72	98	140
9/28/95	825	69	8.1	369											
Count		14	13	14	12							13	9	9	9
Min		49	7.2	318	0.8							0.19	24	48	71
Max		88	9.3	3880	4.7							5.4	470	1200	990
Mean		67	8.2	1084	1.8							0.90	139	255	283
Geo Mean		66	8.2	823	1.5							0.49	95	138	186
Median		68	8.3	712	1.5							0.35	72	100	140

San Luis Canal at Henry Miller Road (MER532)

Location: Latitude 37 06' 00" Longitude 120 49' 13". In SE 1/4, SW 1/4, SE 1/4, Section 36, T10s, R10E.
The site is 3 miles northeast of Los Banos at the Los Banos Wildlife Refuge.

Date	Time	Temp °F	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/7/94	1030	68	8.2	773	1.7							0.28			
10/12/94	920	61	8.4	751	1.5							0.30			
10/20/94	1025	64	8.1	619	1.7							3.40			
10/27/94	1100	62	7.6	704	1.3							0.27	120	64	140
11/22/94	1020	49	8.4	801	2.1							0.39	120	110	160
12/29/94	1120	50	8.9	926	5.4							0.49	130	150	200
1/26/95	1225	56	7.8	2070	16							2.60	250	540	460
2/23/95	1050	60	7.8	4040	57							6.10	470	1200	1100
3/29/95	1210	67	8.0	4320	61							6.10	510	1300	1200
4/13/95	1342	66	8.0	2280	0.8							0.19			
4/28/95	1310	67	7.8	503	2.2							0.50	42	96	120
5/25/95	1055	68	7.4	330	0.9							0.27	25	50	84
6/28/95	950	72	8.1	657	2.4							0.57	59	110	140
7/27/95	1155	81	8.2	555	2.4							0.47	53	94	130
8/31/95	1225	78	8.3	600	2.2							0.36	68	94	130
9/28/95	835	69	7.9	386	1.8							0.24	36	60	100
Count		16	16	16	16							16	12	12	12
Min		49	7.4	330	0.8							0.19	25	50	84
Max		81	8.9	4320	61							6.1	510	1300	1200
Mean		65	8.1	1270	10							1.4	157	322	330
Geo Mean		64	8.0	909	3.2							0.64	99	158	208
Median		67	8.0	728	2.2							0.43	94	103	140

San Luis Canal at Highway 152 (MER527)

Location: Latitude 37°03'27", Longitude 120°48'11". In SE 1/4, SW 1/4, SE 1/4, Sec. 18, T.10S., R.11E. North side of Highway 152, 2.5 miles east of Los Banos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/27/94	1027	62	6.9	679	0.8							0.24	110	60.0	130
11/22/94	1100			700	1.8							0.29	110	82	130
12/29/94	1050	50	8.5	809	3.9							0.35	120	110	170
1/26/95	1205	52	7.9	1070	1.1							1.1	120	150	230
2/23/95	1010	60	8.0	1830	10							1.7	210	420	440
Count		4	4	5	5							5	5	5	5
Min		50	6.9	679	0.8							0.24	110	60	130
Max		62	8.5	1830	10							1.70	210	420	440
Mean		56	7.8	1018	3.5							0.74	134	164	220
Geo Mean		56	7.8	945	2.3							0.54	130	128	196
Median		56	8.0	809	1.8							0.35	120	110	170

Porter-Blake Bypass (MER548)

Location: Latitude 37°05'58.5", Longitude 120°49'14.5". In NW 1/4, Sec. 1, T.10S., R.10E. 7.5 miles east of the intersection of Henry Milller and Mercy Springs Roads. 2 miles north of Los Banos.

Date	Time	Temp °F	pH	EC μmhos/cm	Se μg/L	Mo μg/L	Cr μg/L	Cu μg/L	Ni μg/L	Pb μg/L	Zn μg/L	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/7/94	1040	66	8.1	797	1.7							0.3			
10/12/94	925	58	8.5	786	1.9							0.3			
10/20/94	1035	64	7.8	2560	41							0.3			
10/27/94	1053	63	7.1	2550	29							3.3	320	650	560
11/22/94	920	46		3520	40							4.7	410	1000	780
12/29/94	1140	50	8.1	3200	33							4.3	400	890	790
1/26/95	1240	54	7.7	2150	17							2.7	250	540	500
2/23/95	1100	60	7.8	4160	60	8						6.7	510	1200	1200
3/29/95	1220	65	8.0	4330	60							6.1	530	1400	1200
4/13/95	1348	65	8.0	3860											
4/28/95	1340	67	8.0	4170	69							6.0	520	1400	1100
5/25/95	1105	71	7.6	3380	56							4.7	370	980	820
6/28/95	1005	74	7.6	3100	42							4.5	310	980	820
7/27/95	1215	82	7.8	2660	40							4.0	300	790	610
8/31/95	1220	78	8.0	2980	45							3.8	310	900	730
9/28/95	905	70	7.7	2570	36							3.6	290	730	520
Count		16	15	16	15	1						15	12	12	12
Min		46	7.1	786	1.7	8						0.3	250	540	500
Max		82	8.5	4330	69	8						6.7	530	1400	1200
Mean		65	7.9	2923	38	8						3.7	377	955	803
Geo Mean		64	7.8	2656	27	8						2.6	366	920	769
Median		65	7.8	3040	40	8						4.0	345	940	790

San Luis Spillway Ditch at Santa Fe Grade (MER537)

Location: Latitude 37°08'37.2", Longitude 120°52'22.9". In SE 1/4, SE 1/4, Sec. 16, T.9S., R.10E. 3.4 miles NW of the intersection of Mercy Springs Road and Santa Fe Grade. 5.5 miles north of Los Banos.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/27/94	1151	63	7.7	696	0.4							0.33	110	60	140
11/22/94	845	48		907	0.7							0.45	140	82	160
12/29/94	1240	50	8.2	1060	0.6							0.66	160	110	190
1/26/95	1340	55	7.9	819	0.8							0.78	72	110	240
2/23/95	1110	60	8.0	1170											
Count		5	4	5	4							4	4	4	4
Min		48	7.7	696	0.4							0.33	72	60	140
Max		63	8.2	1170	0.8							0.78	160	110	240
Mean		55	7.9	930	0.6							0.56	121	91	183
Geo Mean		55	7.9	915	0.6							0.53	115	88	179
Median		55	7.9	907	0.6							0.56	130	96	180

APPENDIX C

Mineral and Trace Element Water Quality Data for Outflow Monitoring Stations
Listed in Order by Map Index Number

Mud Slough at Newman Gun Club (MER551)

Location: Latitude 37°18"33", Longitude 120°57'18". In NW 1/4, NW 1/4, SW 1/4, Sec. 23, T.7S., R.9E. 1.7 miles NE of Santa Fe Grade, 1.2 miles north of Highway 140. 4.2 miles NE of Gustine.

Date	Time	Temp °F	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/27/94	1025	66	7.7	1300	0.7		5	3	5	14	7	0.8	200	160	270
11/22/94			8.4	1900	0.7			<1				1.1	290	290	340
12/29/94	1206	47	7.6	1730	0.9							1.1	270	250	300
1/26/95	1215	52	8.6	1300	0.8			7				1.0	170	210	260
2/23/95	1310	59	7.8	2820	0.9							2.2	420	500	520
4/26/95	1040	71	7.9	938	4.2							0.8	120	170	190
6/28/95	1210	71	8.0	2770	1.3							1.8	430	600	500
7/27/95	1430	89	8.7	1374	1.8							1.0	190	260	280
8/31/95	955	76	8.1	1210	1.4							0.8	160	200	250
9/28/95	945	65	7.6	2840	1.1							1.6	410	690	580
Count		9	10	10	10		1	3	1	1	1	10	10	10	10
Min		47	7.6	938	0.7		5	3	5	14	7	0.8	120	160	190
Max		89	8.7	2840	4.2		5	7	5	14	7	2.2	430	690	580
Mean		66	8.0	1820	1.4		5	3	5	14	7	1.2	266	333	349
Geo Mean		65	8.0	1692	1.2		5	2	5	14	7	1.1	243	292	328
Median		66	8.0	1550	1.0		5	3	5	14	7	1.1	240	260	290

Mud Slough (north) at San Luis Drain (MER542)

Location: Latitude 37°19'50", Longitude 120°57'03". In NW 1/4, NE 1/4, NW 1/4, Sec. 14, T.7S., R.9E. 5.0 miles east of Gustine, 3.5 miles SE of Highway 140. Located within Kesterson N. W. R.

Date	Time	Temp °F	pH	EC µmhos/cm	Se	Mo	Cr	Cu µg/L	Ni	Pb	Zn	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/7/94	1105	66	7.8	1550	1.4							0.9			
10/12/94	1100	63	8.1	1410	0.6							0.9			
10/20/94	1115	64	7.8	1300	0.8							0.8			
10/27/94	1239	64	7.9	1370	0.6	12						0.9	220	170	280
11/8/94	1005	50	8.0	1460	0.9							0.9			
11/10/94	1045	54	7.9	1860	0.5							1.2			
11/18/94	1040	50	8.2	1810	0.4							1.1			
11/22/94	1215		8.1	1770	0.4	9		<1				1.1	270	250	310
12/1/94	1300	47		1690	0.4							1.0			
12/9/94	1054	44		1710	0.5							1.1			
12/15/94	1145	47		1800	0.5							1.1			
12/21/94	1202	48		1880	0.5							1.3			
12/29/94	1019	46	7.5	1790	0.7	6						1.2	290	260	310
1/5/95	1051	49	7.7	1730	0.8							1.1			
1/12/95	1100	54	7.7	1520	0.7							1.1			
1/19/95	1040	48	7.7	1240	0.6							1.0			
1/26/95	1405	52	8.9	1000	0.7	2		13				0.9	110	150	250
2/3/95	1450	58	8.1	1490	0.6							1.2			
2/9/95	1320	58	8.3	2370	0.6							1.8			
2/17/95	1345	56	7.8	2570	0.9							1.8			
2/23/95	1215	60	8.0	2360	0.8	7						1.8	340	380	390
3/9/95	1010	57	8.2	2690	0.9							2.0			
3/15/95	1740				1.7							1.0			
3/23/95	900	56	7.1	1660	9.1							1.9			
3/29/95	1425	63	8.3	2040	8.2							2.2	250	400	400
4/5/95	905				5.4							2.4			
4/13/95	1535	64	8.0	2110	1.3							1.8			
4/21/95	1410	63	8.0	1930	1.3							1.6			
4/28/95	1530	69	8.1	1960	1.8	6	11	6	10	<5	6	2.0	71	66	360
5/3/95	1200	73	7.9	2290	17							2.5			
5/12/95	1200	69	8.3	1500	1.4							1.3			
5/26/95	1240	70	8.1	1040	0.9							0.9	130	170	190
6/2/95	1155	72	7.7	1020	1.5							0.7			
6/9/95	1145	70	7.9	1510	1.0							1.0			
6/16/95	1300	71	7.8	1320	1.4							1.0			
6/23/95	1130	80	8.1	1490	0.8							1.0			
6/28/95	1410	78	8.1	2440	1.7							1.8	300	490	440
7/6/95	1115	78	8.3	1570	2.8							1.1			
7/13/95	1050	76	7.6	943	1.2							0.6			
7/20/95	1110	80	8.1	1490	1.4							1.1			
7/27/95	1115	90	7.6	1030	1.2	2	37	12	34	<5	31	0.7	140	200	220
8/10/95	1050	77	7.9	2730	2.7							1.7			
8/17/95	1120	76	8.3	1460	2.5							0.9			
8/24/95	1225	84	7.7	1080	1.8							0.7			
8/31/95	1124	74	8.8	1140	1.5							0.9	150	180	250
9/7/95	1104	78	8.5	676	1.4							0.4			
9/15/95	1057	73	7.9	4600	1.2							2.7			
9/22/95	1151	78	8	616	0.9							0.4			
9/28/95	1310	75	8.01	2400											
Count		46	43	47	48	7	2	4	2	2	2	48	11	11	11
Min		44	7.1	616	0.4	2	11	6	10	<5	6	0.4	71	66	190
Max		90	8.9	4600	17	12	37	13	34	<5	31	2.7	340	490	440
Mean		65	8.0	1711	1.8	6	24	8	22	<5	19	1.3	206	247	309
Geo Mean		63	8.0	1601	1.2	5	20	4	18	<5	14	1.2	186	217	299
Median		64	8.0	1570	1.0	6	24	9	22	<5	19	1.1	220	200	310

Los Banos Creek at State Highway 140 (MER554)

Location: Latitude 37°16'35", Longitude 120°57'14". In NE 1/4, SW 1/4, SW 1/4, Sec., 35, T.7S., R.9E. South side of Highway 140, 2.9 miles NE of Gustine.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	Mo µg/L	Cr µg/L	Cu µg/L	Ni µg/L	Pb µg/L	Zn µg/L	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
10/27/94	815	62	6.6	908	0.4							0.43	139	62	190
11/22/94	1200	50		1090	0.5							0.60	170	90	210
12/29/94	1131	47	7.6												
1/26/95	1300	52	8.9		0.6							0.33			
2/23/95	1150	61	7.8	2680											
3/23/95	1800	53	8.5	780	2.2							0.73			
3/29/95	1345	63	8.0	1410											
4/13/95	1640	72	7.9	2110											
4/26/95	920	67	7.9	2340	0.7							2.6	360	250	400
5/25/95	940	70	7.5	833											
6/28/95	1125	78	7.8	774											
7/27/95	1405	85	7.8	746	0.9							0.54	76	110	200
8/31/95	1019	73	8.3	710											
9/28/95	1030	72	7.6	1450											
Count		14	13	12	6							6	4	4	4
Min		47	6.6	710	0.4							0.33	76	62	190
Max		85	8.9	2680	2.2							2.6	360	250	400
Mean		65	7.9	1319	0.88							0.87	186	128	250
Geo Mean		64	7.8	1178	0.73							0.67	159	111	238
Median		65	7.8	1000	0.6							0.57	160	100	210

Salt Slough at Lander Avenue (State Highway 165) (MER531)

Location: Latitude 37°14'55", Longitude 120°51'04". In NW 1/4, SE 1/4, SE 1/4, Sec. 10, T.8S., R.10E. 13.0 miles north of Los Banos. 5.0 miles south of Highway 140.

Date	Time	Temp °F	pH	EC umhos/cm	Se	Mo	Cr	Cu	Ni	Pb	Zn	B mg/L	Cl mg/L	SO_4 mg/L	HDNS mg/L
					ug/L										
10/7/94	1120	66	7.8	1660	1.1							0.70			
10/12/94	945	60	8.0	1960	0.8							0.90			
10/20/94	1130	65	7.8	1780	6.5							1.1			
10/27/94	915	63	7.6	2040	15	8	9	4	7	<5	12	1.6	320	380	410
11/8/94	1035	52	8.0	2090	9.1							1.7			
11/10/94	1010	54	8.1	2470	13							2.0			
11/18/94	1100	52	7.8	2540	11							2.0			
11/22/94	1300		8.0	2690	14	14		<1				2.2	380	500	560
12/1/94	1224	47		1820	1.7							1.1			
12/9/94	1116	45		2510	14							2.2			
12/15/94	1213	48		2760	17							2.4			
12/21/94	1242	49		2790	11							2.4			
12/29/94	1051	48	7.4	2440	12	10						2.1	370	500	540
1/5/95	940	50	7.5	2490	14							2.2			
1/12/95	1130	55	7.5	2180	10							2.2			
1/19/95	1120	49	7.5	2550	10							2.7			
1/26/95	1333	53	8.6	2400	17	8		7				2.5	330	520	530
2/3/95	1435	58	8.0	2930	23							3.2			
2/9/95	1250	58	8.0	3350	30							3.9			
2/17/95	1310	56	7.7	3500	37							4.0			
2/23/95	1120	61	7.8	3550	38	11						3.9	470	920	840
3/9/95	1030	58	8.0	3070	30							3.2			
3/23/95	1015	57	6.9	2380	24							3.0			
3/29/95	1310	68	8.1	2990	23							3.0	410	740	660
4/5/95	950				21							3.3			
4/13/95	1450	66	7.7	2590	24							2.6			
4/21/95	1255	62	8.1	2310	26							2.3			
4/26/95	826	68	7.4	2510	26	9	10	7	8	<5	40	2.5	340	620	560
5/3/95	1105	61	8.0	1820	16							1.8			
5/12/95	1230	66	7.9	1910	18							2.1			
5/17/95	1505	72	7.6	1500	16							1.8			
5/26/95	1405	70	7.7	1610	19							1.6	180	360	370
6/2/95	1100	70	7.5	1940	20							1.9			
6/9/95	1310	70	7.6	1690	17							1.8			
6/16/95	1125	66	7.3	2000	18							2.3			
6/23/95	1040	80	8.0	1830	18							2.2			
6/28/95	1315	80	7.8	2070	20							2.4	230	480	470
7/6/95	1150	78	8	2100	19							2.0			
7/13/95	1135	76	7.5	1670	20							1.8			
7/20/95	1150	79	7.8	1610	16							1.9			
7/27/95	1245	86	7.8	1750	17	7	23	10	18	<5	32	2.2	210	430	390
8/10/95	1130	82	8	1790	19							1.9			
8/17/95	1155	75	8.1	1720	17							1.8			
8/24/95	1310	82	7.9	1600	15							1.5			
8/31/95	1050	74	7.8	1460	33							2.3	210	320	320
9/7/95	1140	78	8.4	2070	22							2.3			
9/15/95	1122	77	8.1	1520	14							1.4			
9/22/95	1215	78	7.7	1450	12							1.4			
9/28/95	1110	74	7.6	1490	13							1.3	180	330	300
Count		47	44	48	49	7	3	5	3	3	3	49	12	12	12
Min		45	6.9	1450	0.8	7	9	4	7	<5	12	0.7	180	320	300
Max		86	8.6	3550	38	14	23	10	18	<5	40	4.0	470	920	840
Mean		65	7.8	2186	17	10	14	6	11	<5	28	2.2	303	508	496
Geo Mean		64	7.8	2122	15	9	13	3	10	<5	25	2.1	288	484	475
Median		66	7.8	2070	17	9	10	7	8	<5	32	2.2	330	490	500

APPENDIX D

Mineral and Trace Element Water Quality Data for the San Luis Drain
Listed in Order by Map Index Number

Map Index	RWQCB Site I.D.	Site Name	Page
SLD	MER534	San Luis Drain @ Hwy 152	62

San Luis Drain at Highway 152 (MER534)
Location: LATITUDE 37° 23' 21.9", LONGITUDE 120° 47' 16.2".

Date	Time	Temp °F	pH	EC µmhos/cm	Se	Mo	Cr	Cu µg/L	Ni	Pb	Zn	B mg/L	Cl mg/L	SO4 mg/L	HDNS mg/L
10/27/94	1014	61	7.9	9680	9.1		<1	1	8	<5	<1	18	1200	4300	2900
11/22/94	1055		8.3	8810	6.3			<1				16	910	3300	2700
12/29/94	1035	50	8.2	7780	3.7							15	770	3300	2400
1/26/95	1155	53	8.3	5640	1.1			<1				9.6	580	2200	1800
2/23/95	1000	59	7.8	5030	1.3	57						8.3	520	1900	1500
Count		4	5	5	5	1	1	3	1	1	1	5	5	5	5
Min		50	7.8	5030	1.1	57	<1	<1	8	<5	<1	8	520	1900	1500
Max		61	8.3	9680	9.1	57	<1	1.0	8	<5	<1	18	1200	4300	2900
Mean		56	8.1	7388	4.3	57	<1	0.5	8	<5	<1	13	796	3000	2260
Geo Mean		56	8.1	7160	3.1	57	<1	0.4	8	<5	<1	13	760	2873	2193
Median		56	8.2	7780	3.7	57	<1	<1	8	<5	<1	15	770	3300	2400